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The Forest of Mt. Gedeh, West Java.

A Report on a Collecting Trip.

By Joseph F. Rock.*

The writer was duly commissioned by the Director of the Hawaiian Sugar Planters' Experiment Station to proceed to Java and Burmah for the purpose of collecting seeds, in quantity, of the most promising forest trees occurring on Mt. Gedeh, in West Java; he was also asked to go to Burmah for the purpose of obtaining quantities of seeds of *Taraktogenos Kurzii* King, the well-known Chaulmoogra tree, from the seed of which, Chaulmoogra oil, the only successful remedy in the treatment of leprosy, is derived.

In compliance with his commission, he left Honolulu on May 11th for Japan, where he was to obtain an amendment to his passport, which then read for Japan only. Owing to lack of steamship accommodations between Hongkong and Singapore, the writer was forced to proceed to Swatow and thence to Bangkok, Siam, the only possible way of reaching Singapore. At Bangkok he had his passport further amended, without difficulty, for Burmah and India. While in Siam he investigated the leprosy question and reported in full to Dr. A. L. Dean, President of the College of Hawaii. He is especially indebted to Dr. Mordern Carthew, of the Siamese Public Health Department, who had carried on investigations for several years in leprosy and who was treating leprosy cases in the main prison of Bangkok with Gynocardate of Sodium A, the active principle of Chaulmoogra separated by Dr. Leonard Rogers of Calcutta. Dr. Carthew's reports, both published and unpublished, the writer sent to Dr. Dean, with a quantity of the drug, such as is used by Dr. Rogers and Dr. Carthew. He also obtained seeds of *Hydnocarpus anthelminthicus*, a native of Siam, and there used in the cure of leprosy. It contains practically the same active principle as Chaulmoogra. Notwithstanding reports that the seeds of species of *Taraktogenos* and *Hydnocarpus*

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Entrance to the Botanic Garden at Buitenzorg, Java.
Avenue of *Canarium commune*, or Java almond trees. Each tree is clothed with a species of Aroid, the roots of one of which can be seen on the left in the picture.

will not stand transportation, as they lose their germinating power rather quickly, the seeds sent have already germinated, though they were a month and a half in transit. Other seeds were secured in Siam, one of which is a species of fruit tree known in Siam as *Kathorn*, or scientifically as *Sandoricum indicum*. From Siam the writer proceeded to Singapore by boat, arriving there the first of August. After a short illness he proceeded via the Rhio Archipelago and the Island of Biliton to Batavia, Java. Immediately he took the train near the landing at Tandjong Priok for Buitenzorg, the seat of the government of Java, situated on the Volcano of Salak.

The authorities were exceedingly kind to him, and he renewed acquaintances from his last visit to Java in 1916. Work immediately began in the Botanic Gardens and seeds were collected through the kindness of Mr. Wigman, Curator

A group of palms in the gardens at Buitenzorg; the large palm in the center is *Schelea regia*.

of the Garden. The Director of the Garden was most hospitable and aided the writer in every way, so that his mission was successful. He is especially indebted to the Director of Agriculture, Mr. Sibinga Mulder, for privileges granted; to the Chief of Laboratories of the Treub Laboratory, and to Dr. H. S. Koorders for many valuable suggestions, kindness and hospitality.

Fitted out with permits, the writer proceeded to Tjanjor by train, where he took a motor to Tjipanas; coolies had previously been arranged for and were awaiting him at the Tjipanas post office. From there the ascent was begun to Tjibodas, where are situated the Treub Botanical Laboratory for visiting foreign and local biologists and the acclimatization gardens; this is at an elevation of 4500 feet. Tjibodas is situated on the slopes of the active Volcano of Gedeh, and immediately back of the laboratory commences one of the finest forest reserves in Java. It is in this reserve that the writer collected and caused to have collected

seeds of all the forest trees which were then in fruit; he not only collected seeds of trees, but also of shrubs and herbaceous plants, which, together, make up the plant associations on Mt. Gedeh. Including the seeds collected at the gardens at Buitenzorg, the writer had over three hundred and fifty species of trees and shrubs represented in the collection. A number suffered considerably on the voyage

The Treub Laboratory for visiting botanists at Tjibodas, Mt. Gedeh, Java. The large tree to the left, near house, is *Altingia excelsa*, the *Rasamala* tree of Java.

through the tropics and especially in the hold of the steamers in transit, so that the number of species of seeds introduced amounts to 287.

Owing to lack of time and also funds he was unable to proceed to Burmah, and after carefully packing the seeds in charcoal, etc., he proceeded to Singapore and thence to Japan, where he boarded the steamer Nippon Maru on October 4 for Honolulu. In order to give an idea of the forests of Gedeh and the work carried on there by the Dutch Government, the writer will give a more or less detailed account of the forest reserve on that mountain. He not only stayed at Tjibodas, whence he crossed the forests in every possible direction, but he also camped at the second rest-house, Kandang Badak, at an elevation of about 7500 feet. He ascended to the summit crater of Mt. Gedeh, nearly 10,000 feet in height, and collected seeds of the upland trees also. He took numerous photographs illustrating the various floral zones from sea level to 10,000 feet elevation. Owing to the enormous height of the trees, it was, of course, impossible to photograph individual trees, but smaller plants, groups of plants and trunks of the mighty monarchs of the forest were photographed, and a number of these are here reproduced. The photos were all taken by the writer. (The following is a floristic description of the plant covering on Mt. Gedeh.)

Before going into a detailed description of the forests of Gedeh, the writer wishes to give an account of the botanical gardens both at Buitenzorg and Tji-

bodas. Without exception, the gardens at Buitenzorg are the finest in the world; they were founded in 1814 at a time when the location was selected as the seat of the government owing to the cooler climate and much healthier surroundings than prevailed at Batavia. The entrance to the garden is formed by an avenue of *Canarium commune* or Java almond trees, which were planted by Theysmann, the well-known Dutch botanist. To the left is a pond with an island, on which are stately sealing-wax palms, *Cyrtostachys Rendah, Pandani,* etc., while floating in the water are huge *Victoria regia* and numerous other water lilies.

In the acclimatization garden at Tjibodas. In the foreground the renowned grass trees (*Xanthorrhoea*) belonging to the Lilyfamily, (natives of Australian savannahs); elevation 4500 feet.

There are at least ten thousand species of trees and shrubs represented, most of them native of Java and the neighboring islands such as Borneo, Celebes, Sumatra, Amboina, Timor, New Guinea, etc. The palm sections are especially wonderful, as they represent the finest collections of mature palms found in the world.

There are many wonderful Banyan or Ficus trees, *Sterculia* trees with scarlet flowers and the most striking leguminous flowering trees, such as *Amherstia nobilis* and various species of *Brownea* and *Saracca*. Space does not permit to go into detail here, and the few illustrations will have to suffice to give an idea of the marvelous beauty and grandeur of the gardens.

At Tjibodas are situated the acclimatization gardens at 4500 feet elevation. Trees can be found there which are restricted to cooler climes. Of especial interest are the Grass trees *Xanthorrhoea* of Australia, which are growing to perfection, besides huge tree ferns and many conifers.

Immediately back of the garden begins the actual virgin forest. The whole mountain has been set aside as a forest reserve and is known as a "Nature Monument," set aside for study and also for the utilitarian purpose of a watershed.

The forests of Java have been rapidly destroyed, as the area of the island is not too large for the support of about 34,000,000 people. Agriculture has encroached onto the slopes of mighty mountains and consequently the forests had to go. The Government took steps in time to prevent the complete destruction of forests by setting aside forest reserves or "Nature Monuments" in various parts of Java. The forests of Gedeh are by far the finest in the whole of Java. The forest is inhabited by many beautiful birds; also monkeys, barking deer, snakes, etc. These it is not permitted to hunt, and signs are posted near the approach to the actual forests giving notice of certain rules which must be obeyed while on the premises.

View of a portion of the acclimatization garden at Tjibodas, Mt. Gedeh.

At the edge of the forest, at 4500 feet elevation, the Government erected a botanical laboratory, and also living quarters for visiting biologists, by far the greater number of which are botanists. The charges for rooms are very nominal. Permits are issued by the Director of the Botanical Garden and the Chief of Laboratories.

Owing to the facilities extended, the forests of Gedeh have been studied extensively. Dr. Koorders has just published the results of his researches in a work entitled, "The Flora of Tjibodas."

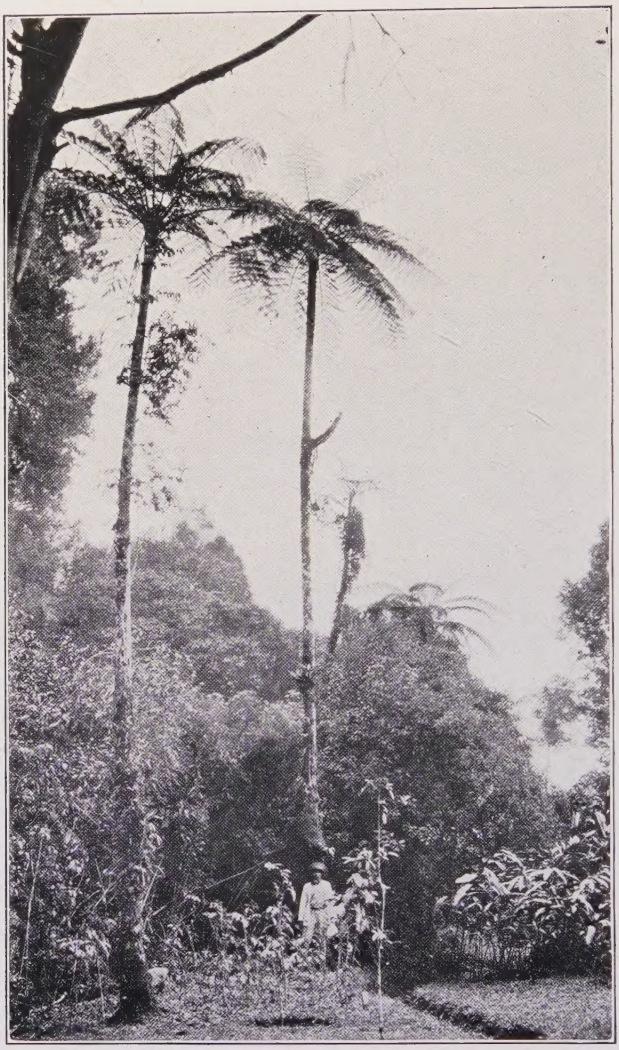
He has studied these forests since 1890, at which time he selected a few specimens of each tree species occurring in the forest, labelled them and took growth measurements of their trunks since that time. Each tree bears a number and name, and under each number in separate publications and in the first part of his Flora of Tjibodas he has published the rate of growth both in height and diameter of trunk.

The Forest of Gedeh is composed of 165 species of trees, 350 species of

Castanea tungurut Bl. One of the species of chestnut at the entrance to Gedeh forest reserve; the tree is over 90 feet high and has a diameter of 50 inches.

shrubs and herbs, and 60 species of climbing plants; these make up the virgin forest, which has preserved its original character because man has left it almost or entirely undisturbed. Its trees remain standing until they die a natural death or succumb in the struggle with their neighbors, and thereafter their corpses sink into the ground, moulder away and leave a bare space where other species commence to battle.

In this as well as other tropical rain forests we find usually so many stories of plants that the whole nearly forms a single complex of vegetation, or, in other words, forest is piled upon forest. The trees forming the highest story on Mt. Gedeh are the Rasamala trees *Altingia excelsa*, reaching a height of 180 feet. At the higher levels their place is taken by a similarly tall tree, *Podocarpus imbricata*, a conifer of the family *Taxaceae*.



Tree ferns on Mt. Gedeh. *Alsophylla glauca* var. *densa*. These ferns are about 50 feet in height. They are very common in the forests about Tjibeurum, Mt. Gedeh.

Junghun, the famous naturalist and writer on Java, distinguished four zones on Gedeh which the writer will describe here briefly.

The early morning and up to ten o'clock is usually sunny, and also the peaks of both Gedeh and Pangerango are clear. Clouds begin to gather around the summit of the mountains rather early, and gradually descend to 5000 feet elevation. The sun shines usually at noon at Tjibodas, while a little later fog envelops the whole mountain and downpours begin at about two o'clock. At five in the evening the atmosphere clears again, and while it darkens again later in the evening, the summit can often be seen at sunset time. The nights and early mornings are, however, usually clear.

The first zone, or hot region, is from sea level to 2000 feet, and does not interest us here, as it does not contain forest trees of any extent, especially as

Trunk of *Altingia excelsa* Nor. The Rasamala is the tallest forest tree of Java, reaching a height of 180 feet. Ferns, mosses, liverworths and climbing aroids cover the trunk. In the second zone, elevation 4600 feet.

The views which follow are arranged in about the order they were photographed in ascending the mountain to its summit.

the forests of Gedeh commence actually with the second or temperate zone, from 2000 to 4600 feet and over. The cool region is from 4600 to 7600 feet, and the cold, including the alpine region, from 7600 to 10,000 feet.

The Temperate Region.

The forests of the second zone, which correspond in Hawaii to our 2000-foot level, are especially pronounced, owing to the various species of figs which here predominate. Mention may be made of the enormous species of *Ficus involucrata,* which reaches large dimensions, especially as to size of trunk (see plate). The tree reaches a height of over 100 feet or more and has a trunk diameter of nearly six feet. Other species and the next in size is *Ficus varie-*

Forest scene; the trees are mostly Poespa—*Schima Noronhae*. The undergrowth is composed mainly of Bubukuan—*Strobilanthus cernua*; the fern to the right on the trunk is *Asplenium nidus*, the bird's nest fern.

gata, reaching a height of 80 feet, with a trunk diameter of about four feet; *Ficus ribes* is a smaller species, and so are *Ficus alba*, *Ficus cuspidata*, and *Ficus rostrata*, of all of which the writer brought back quantities of seed. Especially common was *Ficus variegata*, which has a fruit nearly the size of the ordinary Smyrna fig, and which is said to be edible.

The most striking of all trees in this region is the Rasamala tree *Altingia excelsa*, the tallest forest tree of Java; the tree is very common in this region, so that one can speak of a Rasamala zone. The tree reaches a height of 180 feet or more, forms straight boles 120 feet in height before the first branches occur; it towers above everything else in the forest. Seedlings were, however, very scarce and very few young trees were noticed. The old trees are said to fruit very rarely, which accounts for the small number of seedlings. Two trees were

A Rasamala tree, *Altingia excelsa*, in the second zone, covered with epiphytes lianes, etc. The tree reaches diameters of over six feet.

found bearing fruits, but they were still immature and would not be ripe till October. The trunks of Altingia trees are usually from five to six feet in diameter or even more. The writer arranged to have seed of this fine species collected when mature and to have same shipped to Hawaii. The Laurel family is represented by species of *Litsea* as *L. angulata*; associated with it are *Ilex cymosa, Eugenia tenuicuspis, Pandanus laevis, Manglieta glauca* or *Magnolia Blumei,* the latter a synonym of the former. The most striking and numerous trees next to *Altingia* are species of Chestnuts, of which *Castanea javanica* is the most common. It was in full fruit, and the writer kept nine men collecting seeds of that species alone for nearly a week. *Castanea tungurut*, also a large and handsome species, is less numerous and was not in fruit this year; the keeper of the gardens remarked that it bore abundantly the year before and the seeds

Tree No. 3398, *Vernonia arborea* Hmlt. It belongs to the Sunflower family (*Compositae*) and is over sixty feet in height and is nearly twenty-nine inches in diameter. It belongs to the Rasamala zone, 4600 feet elevation. The smaller stems to right are *Tetrastigma papillosum.*

were sent down to the markets, where they were sold in large quantities. Species of *Saurauja* form smaller forest trees; they are very conspicuous on account of their large pendulous whitish flowers. *Elaeocarpus ganitrus* and *E. dentatus* occur also in this zone with *Toona febrifuga,* a meliaceous tree of which large specimens can be found in Honolulu in Mrs. Foster's grounds on Nuuanu Avenue. A very remarkable tree is *Vernonia arborea,* belonging to the Sunflower family; it is not uncommon in this region, and trees a hundred feet in height and trunks of three feet in diameter are not uncommon (see plate).

The undershrub in this zone is mainly composed of zingiberaceous plants; a species of *Impatiens* is common. *Amomum, Elatostemon,* an urticaceous plant, and a few palms as *Plectocomia* and *Calamus,* both climbing species,

Ficus involucrata Bl. This fig tree is 150 feet in height and nine feet in diameter. It is a rival of the Rasamala tree.

while *Pinanga Kuhlii* is the only erect palm present. It ascends, however, into the third zone. Its aspect is quite different from the cultivated plants in the gardens. Of other climbing plants belonging to this region are *Rhapidophora* and *Scindapsus, Nectandra angustifolia,* of which the writer secured an abundance of seed; also *Leea sambucina,* which, while not a real climber, is here a shrub with exceedingly long intertwining branches twenty to thirty feet in length. One species of *Freycinettia,* related to our *F. arborea,* the *Ieie* of the Hawaiians, festoons the trees, but not to the extent of our species in Hawaii. The most remarkable epiphyte is the Bird's Nest fern *Asplenium nidus* (see plate), which festoons most of the trees and ascends to an elevation of 6000 feet, while in Hawaii it rarely goes up to 1000 feet. Only a single apparently wild species of Bamboo ascends into the second or Rasamala zone. Epiphytic ferns are very numerous, especially interesting being *Pleopeltis heraclea,* on the

Tree No. 3073, *Podocarpus imbricatus* Bl. (Syn. *P. cupressina* R. Br.) This conifer is 110 feet in height and nearly five feet in diameter. It is less common in the Rasamala zone.

lower edge of the second zone. Of orchids we find *Dendrobium, Bulbophyllum, Appendicula,* etc.

Other trees worthy of mention as occurring in this region are *Engelhardtia spicata,* belonging to the Walnut family; *Trema orientalis,* to the Elm family, and two huge climbing rutaceous plants with stout spines, *Fagara scandens* and *Toddalia aculeata.*

The Third Forest Zone by Tjibeurum and Kandang Badak.

As we ascend from the Rasamala zone upwards we find that Castanea is absent and its place is taken by several species of Oaks (*Quercus*) and Conifers of the *Taxaceae, Podocarpus imbricatus, Podocarpus amarus* and *Podocarpus neriifolius.* The first mentioned species reaches the highest dimensions and is

Tree No. 3191, *Litsea angulata* Bl. A member of the Laurel family; it is nearly 60 feet in height and over two feet in diameter.

the rival of the Rasamala tree; it reaches a height of 160 feet and a trunk similar to that of the Rasamala. It is also very numerous, so that one could speak of the *Podocarpus* zone. Associated here with it are *Pithecolobium montanum,* one of the few arborescent leguminous trees found on Gedeh; several species of Litsea of the Laurel family, members of the family *Melastomaceae,* as, for example, *Memecylon,* are not uncommon. Here also belongs the rutaceous tree *Acronychia laurifolia,* the cunoniaceous *Weinmannia Blumei*; the latter is, however, not common.

Of Euphorbiaceae we find *Homalanthus populifolius,* with leaves resembling a poplar; an *Antidesma,* and others.

The tree ferns reach here their best development, and fine, handsome tall specimens can be found. They belong to the genera *Cyathea* and *Alsophylla,* the latter represented by *A. glauca* var. *densa,* with specimens of over fifty feet

Showing the trail in the rain forest leading into the Podocarpus belt; ferns are here very numerous; in the foreground Sapiin, the well known Javanese plant collector who knows the native names of most of the plants in this forest reserve.

in height. One of the commonest and finest forest trees next to *Podocarpus* is *Schima Noronhae,* the *Poespa* tree of the natives; it does not only occur in the third forest zone, but descends to the second zone and ascends away into the fourth zone. It is one of the most promising trees, owing to its indifference to climatic conditions. Unfortunately the *Poespa* trees were in full bloom at the time of the writer's visit, but arrangements were made to have seeds of that species sent to Hawaii as soon as available. The forest floor was literally strewn with the handsome large white flowers of the *Poespa,* a member of the Thea family.

Melastomaceae are common—especially fine trees of *Astronia* may be found, besides *Medinella* and others. Smaller plants and shrubs as well as small trees are very common, and the most conspicuous are *Perrottetia alpestris,* the myr-

Bird's nest ferns, *Asplenium nidus*, on *Memecylon*, a tree belonging to the *Melastomaceae*. Other trees in this forest are *Castanea javanica*, *Cedrela*, *Ficus ribes*, etc. The palm *Pinanga Kuhlii* Bl. with pinnate leaves can be seen in the lower part of the picture.

sinaceous species *Rapanea affinis*, *Ardisia javanica*, and others. *Schefflera scandens* is a climbing shrub; *Rhododendrom javanicum*, a gorgeous plant with large orange-red flowers, grows both terrestrially and epiphytically on other trees. Of Urticaceae we still find a species of *Elatostemon*, which covers the walls at the Tjibeurum Waterfalls. Here we still find Bananas (*Musa acuminata*) and the zingiberaceous *Hornstedtia paludosa*. The undergrowth is now mostly composed of a liliaceous plant, *Disporum pullum*, which forms a dense cover. It dies down after producing numerous large lead-blue fruits. Remarkable plants are *Begonia robusta*, *Cyrtandra picta* and *C. grandis*. This region is also the home of *Gunnera macrophylla*, of which Hawaii possesses a close relative, the *Apeape* of the natives, *Gunnera petaloidea*; only the Hawaiian species excels the Javanese species greatly in size of leaves. Orchids to the

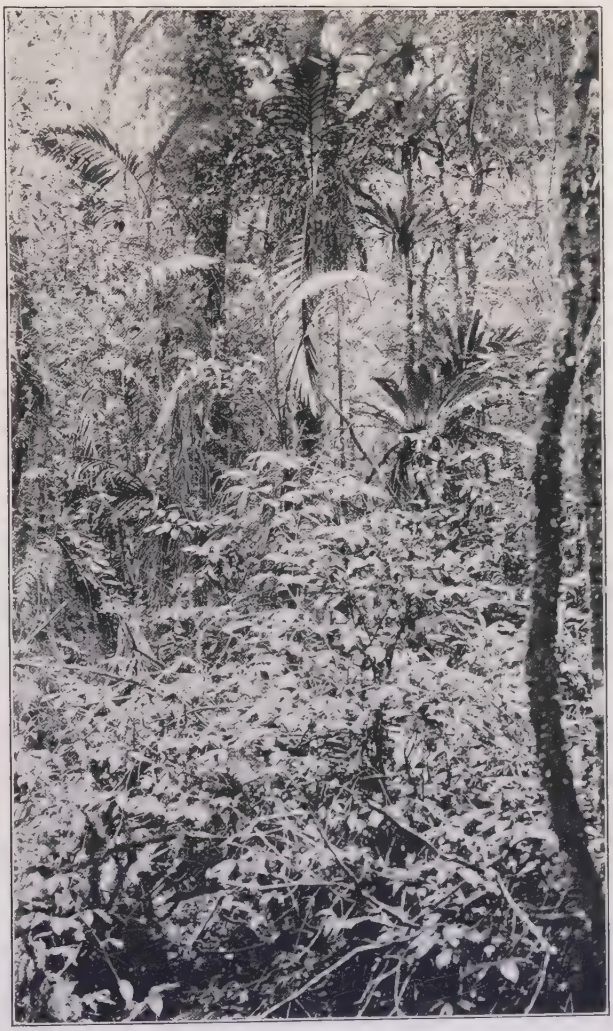
number of 150 clothe trunks of trees; also mosses and liverworths find here their best development. The genus Rubus is here represented by two species, *R. lineatus*, with red, delicious fruits, and another species with yellow fruits less delicious. *Schefflera rigida, Aralia ferox, Rumex crispus* and herbaceous composites belong here also.

The *Ericaceae* reach here a remarkable development For example, *Vaccinium Theysmannii*, related to the Hawaiian Ohelo berry (*Vaccinium reticulatum*), becomes a liana and was observed by the writer climbing a tall Podocarpus trunk in the moss forest to a height of nearly 80 feet (see plate). *Vaccinium*

Mt. Pangerango as seen from the trail to Tjibeurum, Mt. Gedeh. The grass is an *Imperata*, or Lalang grass, a great and dangerous enemy to the forests, like our Hilo grass (*Paspalum conjugatum*), only worse.

varingiifolium, usually densely covered with moss and epiphytic ferns, reaches here a height of nearly 50 feet, with a trunk of about two feet in diameter. Another genus represented here is *Gaultheria* by the very fragrant *Gaultheria fragrantissima*.

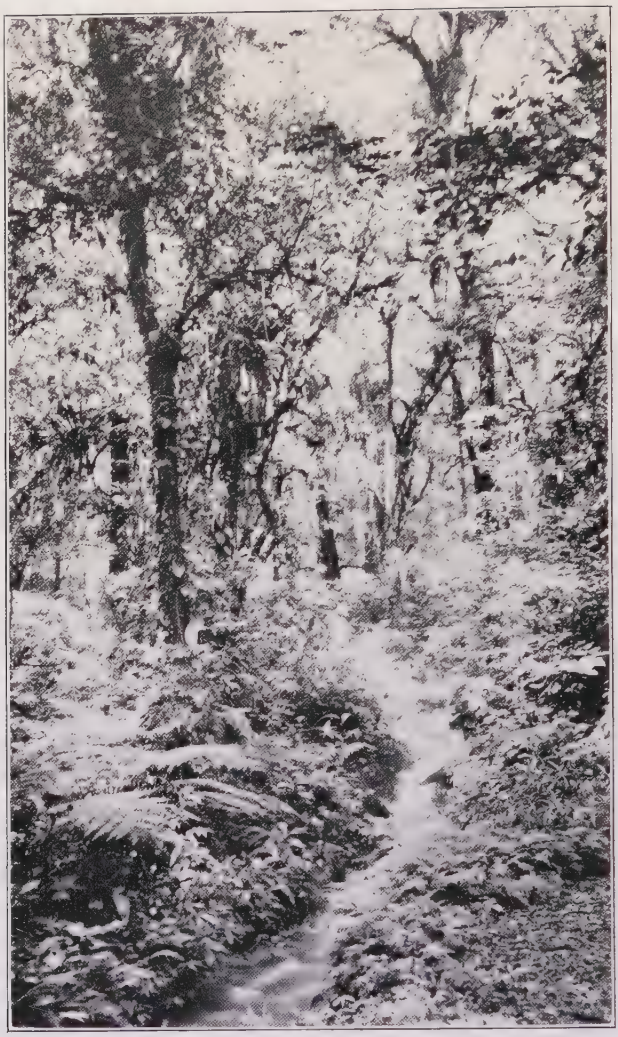
Of herbaceous plants we find a plantain, *Plantago Hasskarlii*, buttercups as *Ranunculus diffusus, R. javanicus, Sanicula europaea*; and of ferns we find species of *Lomaria, Elaphoglossum callifolium, Oleandra neriiformis*, the latter usually a climber. *Pleopeltis Feei* covers open rocky places as near the waterfalls of Tjibeurum, and the epiphytic *Polypodium obliquatum*, which reminds one very much of our *Polypodium adenophorum*. *Hedychium Roxburghii* belongs still in the Podocarpus belt as *Melastoma aspera, Viola serpens*, a small but pretty native violet, and two or three lobeliaceous plants, as *Pratia montana*, with large pale purplish berries and handsome pale blue flowers; also *P. nummularia*, and a climbing species of *Campanumoea* (*javanica*) with carmine berries. The most common orchid, a very beautiful species of *Dendrobium* (*D. Hasseltii*), with purple flowers, festooned the moss-covered trees. The writer



Rain forest on Mt. Gedeh; the slender palms are *Pinanga Kuhlii* Bl. The underbrush is *Strobilanthus cernua;* on the trees, *Asplenium nidus,* the bird's nest fern. Trees are *Nauclea, Schima,* etc.

spent three days at Kandang Badak, a rest-house erected by the Government for visiting scientists. This rest-house is situated at 7400 feet elevation, and consequently the temperature is quite low, especially during the night. The ascent of Mt. Gedeh is made from Kandang Badak. The trail becomes steeper and the moss forest more open; underbrush is scarcer. The trees are of much smaller stature; the predominating species are still *Podocarpus imbricatus, Schima Noronhae,* an occasional Oak or *Quercus,* but the most common species is the Ohelo berry tree, *Vaccinium varingiifolium. Albizzia montana* makes its appearance now for the first time, the moss becomes scarcer, the trees thinner and more straggly as we ascend.

Hypericum Hookerianum was observed as an epiphyte. *Viburnum coriaceum, Schefflera divaricatum* join the other plants mentioned; also *Melastoma*



On the way to Tjibeurum Falls; a little brook in the woods. The trees are *Schima, Quercus, Elaeocarpus.* Of climbers we find *Freycinetia, Agalmyla parasitica,* etc. The trees are festooned with orchids.

setigerum. Vaccinium forms now almost pure stands. They are spindly, small trees till we come to the saddle of Gedeh crater.

The trail descends now and we behold for the first time the Javanese Edelweiss *Anaphalis javanica,* a beautiful shrub or small tree with white woolly lanceolate leaves belonging to the Compositae. *Albizzia montana,* a beautiful small tree (up to 45 feet in height), with bright yellow flowers arranged in dense spikes, is now the commonest tree. It is associated with *Vaccinium varingiifolium, Gaultheria fragrantissima,* the two latter belonging to the Ohelo berry family. Another handsome tree is *Myrica javanica,* which can only be found in this open alpine region. Of rushes, mention must be made of *Gahnia javanica,* which grows among basaltic lava rocks. *Lycopodium Gedeanum,* resembling much the Hawaiian *Lycopodium cernuum* (*Wawaiole*), is a creeper near

Agaimyla parasitica, an interesting plant with large red flowers, belonging to the *Gesnera* family. In the cool of the morning the leaves stand at right angles to the trunk, but in the afternoon they droop. *Freycinetia* can be seen to the right; bird's nest fern on the trunk.

the summit of Gedeh, while at the summit proper, among the rocks, the writer found two species of Gaultheria, one *G. leucocarpa,* with snow-white fruits, a small handsome bush; and the other a small creeper with blackish purple fruits, viz: *Gaultheria nummularifolia.*

The Crater of Gedeh itself showed not much activity; according to statistics it was last in eruption in 1840 and 1886. All that could be seen was steam arising from the wall of the crater, while the floor was smooth and looked like dried mud. Evidences of it being very much alive can be seen in the mossy forest zone, where several boiling hot springs gush forth from the mountain side, which collect into a stream and form the three waterfalls at Tjibeurum.

The Crater of Gedeh is not very large and is only about 200 feet deep.

Forest near Tjibeurum, a typical rain forest of *Quercus, Acronychia laurifolia, Engelhardtia spicata, Schima Noronhae*, etc. The undergrowth is composed of ferns, *Strobilanthus, Impatiens, Carex baccans*, etc.

A wonderful panorama unfolds itself at the top of Gedeh, with clouds at one's feet and the mountain peak of Pangerango to the left, that of Goenoengsela to the right and others in front overlooking the broad plain which descends from here to the foot of the mountain. Just below the summit and near Goenoengsela are many fumaroles or sulphataras.

As has already been stated, the writer collected and caused to have collected seeds of trees from all the different forest zones here described. The list is too long to mention the species here, and as a matter of record it will be published elsewhere.

In conclusion, the writer cannot help remarking about the wonderful care given by the Dutch Government to this reserve. The forests of Gedeh have

One of the three waterfalls of Tjibeurum. A thousand feet or so higher this water comes out of the ground boiling hot, but is cold when it reaches Tjibeurum. The plants along the wall are ferns and a species of *Elatostemon*.

been made easily accessible through well-kept trails, and there is not a second tropical forest which has been visited in the last decade by so many naturalists from all parts of the world. Gedeh is not the only Nature Monument set aside by a wise government in Java; a number occur and are distributed throughout the Island. They have not only been set aside, but are assiduously studied by foresters, botanists and biologists. Trails dissect the mountain slopes in several directions, and it is along these trails that trees are labelled with their scientific names and numbers. A map of this forest region is about to be published, showing these trails and the location of the various marked trees along the trails. A list has been published of these trees, and one need only refer to the number in the list, which furnishes all available data about that particular tree since 1890.

Gunnera macrophylla and *Cyrtandra picta*, near the foot of the larger of the three falls at Tjibeurum. Like the Hawaiian *Gunnera petaloidea*, this species also loves the sprays of waterfalls and rocky cliffs.

No trees are allowed to be felled, and the collecting of plants is permitted for scientific purposes only. While the forests have been more or less thoroughly explored, still visiting botanists have every now and then discovered new plants or plants not previously recorded from Gedeh. Many eminent biologists have visited Gedeh and each carried on his or her particular line of investigation, with the result that there is a volume of literature on the forest of Gedeh and West Java proper which have enabled the Government to care for their forest reserves in the most scientific and efficient manner. While they have expended and are expending large sums of money for the upkeep of their gardens, laboratories and living quarters for visiting scientists, they have reaped untold benefit by the investigations carried on by both their local and visiting scientists.

In the Podocarpus forest. The tall tree is *Podocarpus imbricatus* associated with Poespa—*Schima Noronhae*, *Quercus induta*, etc. Occasional bird's nest ferns are still prevailing in this region.

Such a nature monument it would be wise to establish in Hawaii, and there should be formed a society for the protection of our forests, whose aim should be the establishing of nature monuments under government supervision.

Trails should be cut properly and not promiscuously by private individuals without supervision, and rest-houses established with facilities for scientific work.

We may well learn a lesson from the Dutch Government in proper forest management. By adopting similar methods we would attract scientists from all parts of the world, especially from our mainland institutions of learning, as the Hawaiian Islands are more easily accessible than Java, in the southern hemisphere.

Cyrtandra grandis in the moss forest, 6500 feet elevation. It is not very common and does not descend into the Rasamala forest. It is one of about eighteen species occurring in Java, one of four found on Gedeh; in Hawaii we have about ninety species and varieties of this genus; they are all members of the rainforest.

Synopsis of the More Important Plant Families Occurring on Gedeh and Their Relatives in Hawaii.

Gymnosperms.

The Taxaceae is represented on Gedeh by three species, of which *Podocarpus imbricatus* is the most common. In Hawaii Gymnosperms are entirely absent.

Monocotyledones.

Of *Pandanaceae* (Pandanus family), *Pandanus lais* occurs in the second

Dense moss forest 7000 feet elevation. The large trunk to the left is *Podocarpus imbricatus*, covered with moss; the stout liane climbing up the trunk is *Vaccinium Teysmannii*; it ascends eighty feet into the crown of the tree; it belongs to the Ericaceae and to the same genus as the Hawaiian *Ohelo* berry.

forest zone. In Hawaii the genus is represented by one species, *Pandanus tectorius,* but with four varieties, none of which go higher than 1000 feet.

The genus *Freycinetia* is represented by two species on Gedeh, *F. insignis* and *F. javanica,* while in Hawaii we find only one species widely distributed through our archipelago (*F. arborea*).

Of *Gramineae,* grasses are only sparingly found on Gedeh and are absent in the upper forest.

A *Bambu* (*Dinochloa scandens*) occurs in the second, but goes also into the third zone on Gedeh. In Hawaii we have only one Bambu (*Bambusa vulgaris*), which is restricted to the lowlands.

Trunks of *Vaccinium varingiifolium*, the Javanese "Ohelo" berry tree. Trees fifty feet in height and two feet or more in diameter are not uncommon. The fern in the foreground is *Lomaria vestita*; on the moss-covered trunk *Elaphoglossum callifolium*. The trunk to the extreme right is *Podocarpus imbricatus*.

Of *Cyperaceae* or rushes only few are found on Gedeh, especially common being *Carex filicina* and *Carex baccans*; *Gahnia javanica* occurs near the summit in the alpine region. In Hawaii *Carex* occurs in the lower forest zone and up to, or over 5000 feet in the swamp forests. *Gahnia* is represented by several species, one *Gahnia* (*Beechey*) resembling *Gahnia javanica*. Some of the Hawaiian species are dry-district plants, and one or possibly two occur in the high swamp lands.

Of Palms we find on Gedeh only pinnate-leaved species, none of which have any relatives in Hawaii, where the fan-leaf type (*Pritchardia*) only occurs.

The *Araceae* or *Aroid* family is sparsely represented on Gedeh with the exception of two root-climbers of the genus *Rhapidophora*. Hawaii has none.

Kandang Badak rest house at an elevation of 7500 feet. From here the summit of Mt. Gedeh can be reached in about two or three hours. *Alsophylla* tree ferns, *Urticaceae*, *Astronia spectabilis*, *Viburnum coriaceum*, *Melastoma setigerum*, etc., from the trees and shrubs. In the extreme lower left on the wall is *Rumex crispus*. Two species of Rubus occur here also.

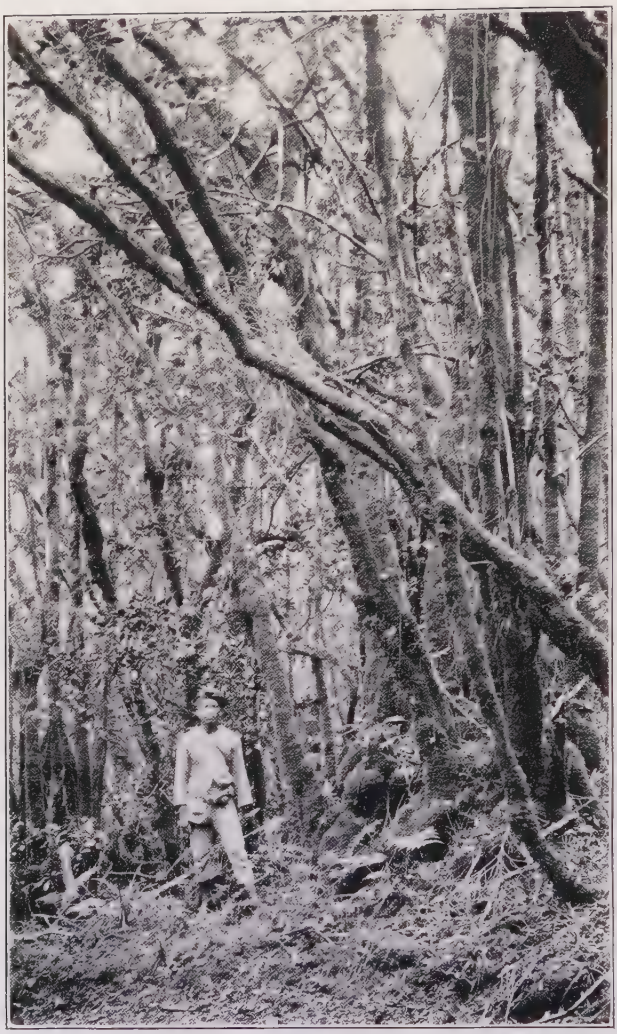
The *Commelinaceae* have five species on Gedeh, of which one, *Forestia glabrata*, is common. Hawaii has none or only the introduced *Commelina nudiflora*, the *Honohono*.

Of *Liliaceae* (Lily family), *Disporum pullum* is the commonest species and forms pure stand as undergrowth, and dies down after fruiting.

In Hawaii no relatives of that genus are present.

Dianella occurs both on Gedeh and in Hawaii, but is represented by different species.

Of *Musaceae* (Banana family), only one species (*M. acuminata*) occurs on Gedeh; in Hawaii *M. sapientum* is represented by many non-seed-bearing native varieties in similar locations as *M. acuminata* on Gedeh.



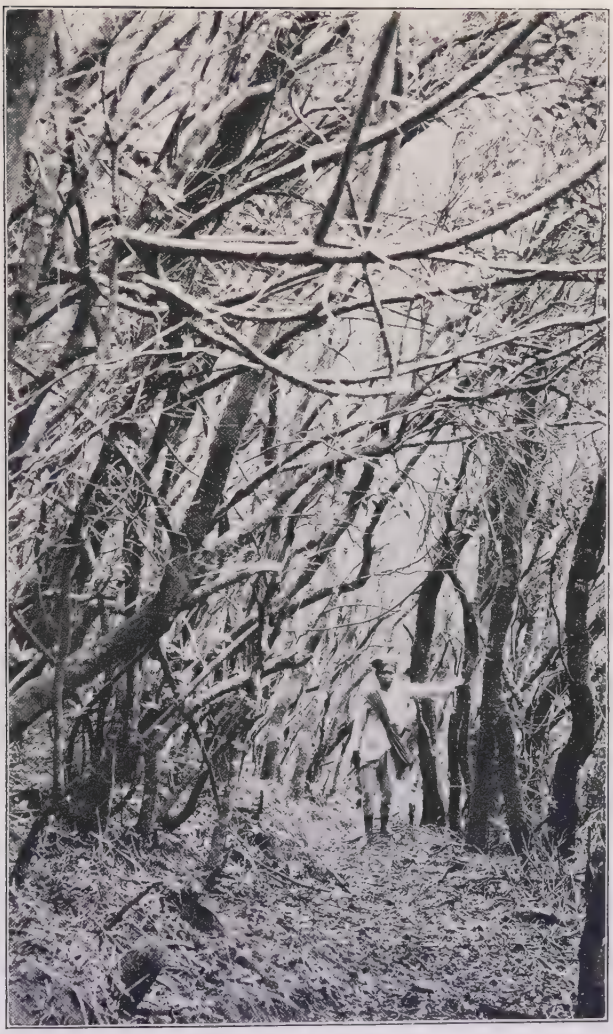
Moss forest with smaller trees at nearly 7800 feet elevation. The trees are *Vaccinium varingiifolium, Schima Noronhae, Elaeocarpus, Melastoma setigerum, Schefflera, Viburnum,* etc. The beautiful orchid *Dendrobium Hasseltii* with purple flowers is very common in this cold, foggy region.

Zingiberaceae or ginger family is represented by numerous species in the lowlands but only by few species in the third zone. Hawaii has only one zingiberaceous plant, namely, *Zingiber zerumbet,* peculiar to the lower forest zone.

Of *Orchidaceae,* Gedeh possesses 150 species, the majority of which are epiphytes, while only a few are terrestrial. *Dendrobium* is represented by 20 species, *Bulbophyllum* by 15, *Apendicula* by 6, *Liparis* by 8. Hawaii is exceedingly poor in orchids and possess only three genera, of which each is represented by a single species. The genera found in Hawaii are *Liparis, Anoectochilus,* and *Habenaria.*

Dicotyledones.

Of *Piperaceae,* two species of *Peperomia,* of which one, *P. reflexa,* occurs



The last stands of trees, mostly composed of *Vaccinium*s, *Kimarak*, and *Ganapura*. Note the absence of moss.

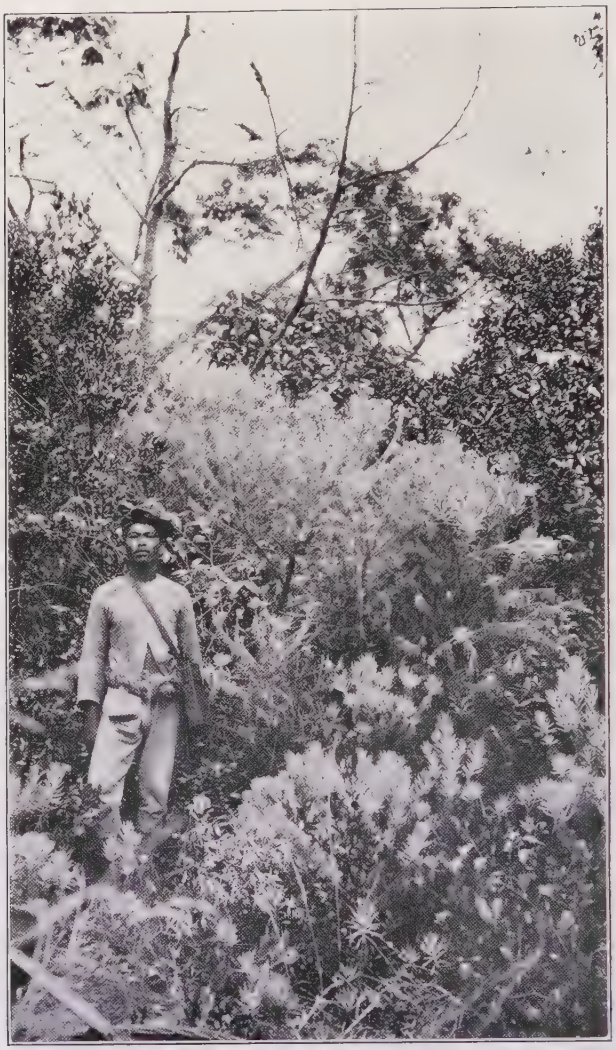
also in Hawaii, ascends into the third region. Hawaii possesses over 75 species of *Peperomia*, while *Piper*, which is represented by three species on Gedeh, is only represented by the cultivated species *P. methysticum*.

The *Juglandaceae* or Walnut family has two species of *Engelhardtia* on Gedeh. In Hawaii the family is unknown.

The *Fagaceae* or Chestnut family has nine species of oaks and three species of chestnuts on Gedeh; in Hawaii the family is absent.

To the *Ulmaceae* belong three species of the third and first zones; *Trema orientalis*, however, belongs to the first zone. In Hawaii we have *Trema amboinensis*, which is, however, very rare.

The *Moraceae* or fig family possess quite a number of species of *Ficus*, of



In the upper outskirts of the forest approaching the summit of Gedeh. The white plant in the foreground is *Anaphalis javanica*, the Javanese Edelweiss; the trees in the back are Vaccinium and Gaultheria fragrantissima; elevation about 9000 feet.

which *Ficus ribes, F. variegata, F. involucrata* and *F. alba* are very common in the second zone. Hawaii has none.

Of *Urticaceae* (Nettle family), the genera *Boehmeria, Pilea* are represented on Gedeh and in Hawaii, in the latter place each genus by one species. Other genera as *Elatostemon Debregeasia* and *Villebrunia,* etc., are found on Gedeh but not in Hawaii. Species of *Elatostemon* form the common undershrub in the Gedeh forest.

Of *Proteaceae* or *Grevillea* family only a single species (*Helicia serrata*) is found on Gedeh; in Hawaii the family is absent. Only a single species of *Henslowia* (*umbellata*) belonging to the *Santalaceae* occurs on Gedeh, while Hawaii possesses several species of *Santalum* and three species of *Exocarpus.*

The *Amaranthaceae* are represented on Gedeh by a few weeds restricted to the lower forest border; one of them, *Amarantus spinosus*, occurs also in Honolulu in waste places. Hawaii possesses a genus of trees belonging to this family.

Of *Ranunculaceae*, or Buttercup family, there are to be found on Gedeh two species of *Clematis* and two species of *Ranunculus*. The latter genus is represented in Hawaii also by two endemic species.

While the *Magnoliaceae* are absent in Hawaii, the family is represented on Gedeh by several species, important of which is *Magnolia Blumei*.

Near the summit of Gedeh. The trees are *Vaccinium, Gaultheria fragrantissima*; tree next to Javanese, *Myrica javanica*, and in the background, extreme right, *Albizzia montana*. The white plants in immediate foreground are *Anaphalis javanica*.

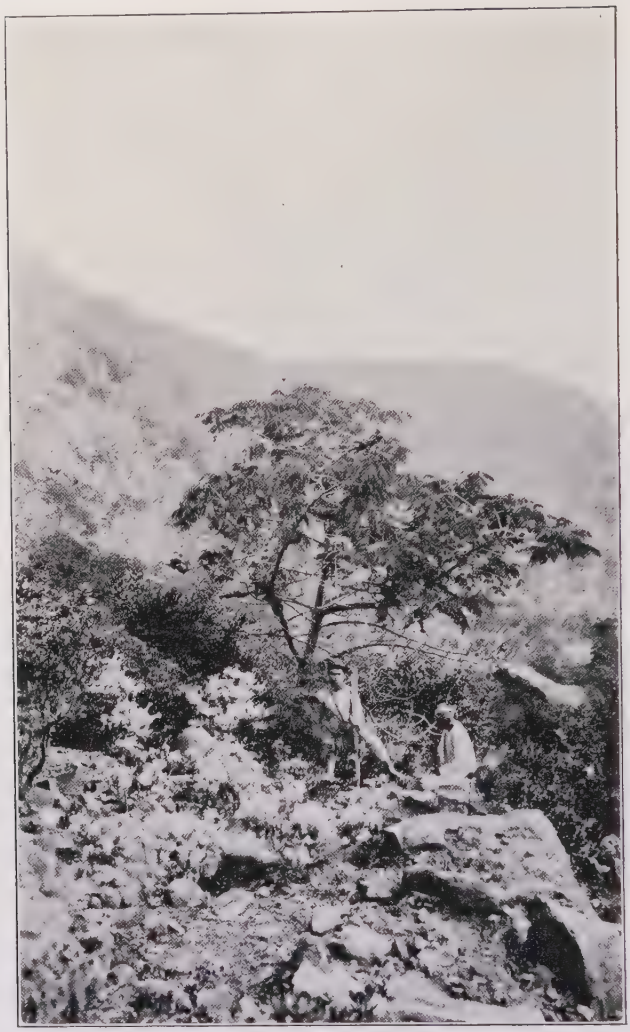
The *Lauraceae* form a very important plant family on Gedeh and are represented by sixteen species of trees, of which several reach large dimensions; especially noteworthy is the genus *Litsea*. In Hawaii there is only a single species of *Cryptocarya* to be found, and that only on the Island of Kauai, where it is known as "*Holio*."

The *Pittosporaceae* are represented by a single tree, while Hawaii has quite a number of species of the genus *Pittosporum*.

The *Hamamelidaceae* have one tree species on Gedeh, the well-known Rasamala tree, the tallest tree in Java.

Of *Leguminosae* only two tree-species can be found, *Albizzia montana* and *Pithecolobium montanum*. Hawaii is also poor in *Leguminosae*.

The *Rutaceae* are scarce on Gedeh and are represented by one tree (*Acronychia laurifolia*) and two liana. Hawaii is rich in *Rutaceae*, as f. e. *Pelea*, related to *Acronychia*, *Zanthoxylum*, and *Platydesma*.



Albizzia montana, the most common tree on the summit of Gedeh. It is a handsome tree with large spikes of brilliant yellow flowers; elevation 9000 feet or more. *Anaphalis javanica* in the foreground.

The *Meliaceae* have four large tree-species, of which *Toona febrifuga* is one of the important ones. The family is absent in Hawaii.

Of *Euphorbiaceae,* only few species can be found on Gedeh, the most common forest tree being *Homolanthus populifolius.* Hawaii possesses many species of *Euphorbia,* two species of *Claoxylon* and two of *Antidesma* and others.

The *Aquifoliaceae* and *Celastraceae* have each one species on Gedeh belonging to the genera *Ilex* and *Perrottetia* respectively. The same genera are represented by one tree-species each in Hawaii.

The *Elaeocarpaceae* have several species of *Elaeocarpus,* as f. e. *E. stipu-*

A rush, *Gahnia javanica*, near the summit of Gedeh. There are several species of *Gahnia* in Hawaii. Bushes in the background are *Gaultheria leucocarpa*, a white-fruited relative of the Hawaiian Ohelo berry.

laris, E. acronodia, E. ganitrus, etc. Hawaii has a single species, *E. bifidus,* peculiar to Oahu and Kauai.

The *Dilleniaceae,* while absent in Hawaii, are represented on Gedeh by seven species of *Saurauja* and *Actinidia callosa,* a rare climbing shrub.

The *Theaceae,* or Thea family, have three species of *Eurya* and the common *Poespa* or *Schima Noronhae.* Hawaii has a single species of *Eurya.*

The *Myrtaceae* possess a species of *Leptospermum* on Gedeh and several species of *Eugenia.* The latter genus is represented in Hawaii by a single species, but has two other species of that family belonging to genera closely allied to *Eugenia.*

Mount Pangerango with clouds seen from near the summit of Mt. Gedeh; elevation 3019 m.

The *Melastomaceae* have several species, noteworthy of which is the common tree *Astronia spectabilis*. Hawaii has no species belonging to this family.

The *Halorhagaceae* have two species of *Gunnera* on Gedeh, and one species of *Gunnera* in Hawaii.

The *Ericaceae* are important for Gedeh. One species of *Vaccinium* is a tree. In Hawaii there are several species of that genus, but all are shrubs. The genus *Gaultheria* has three species on Gedeh and one species of *Rhododendron*; both genera are absent in Hawaii.

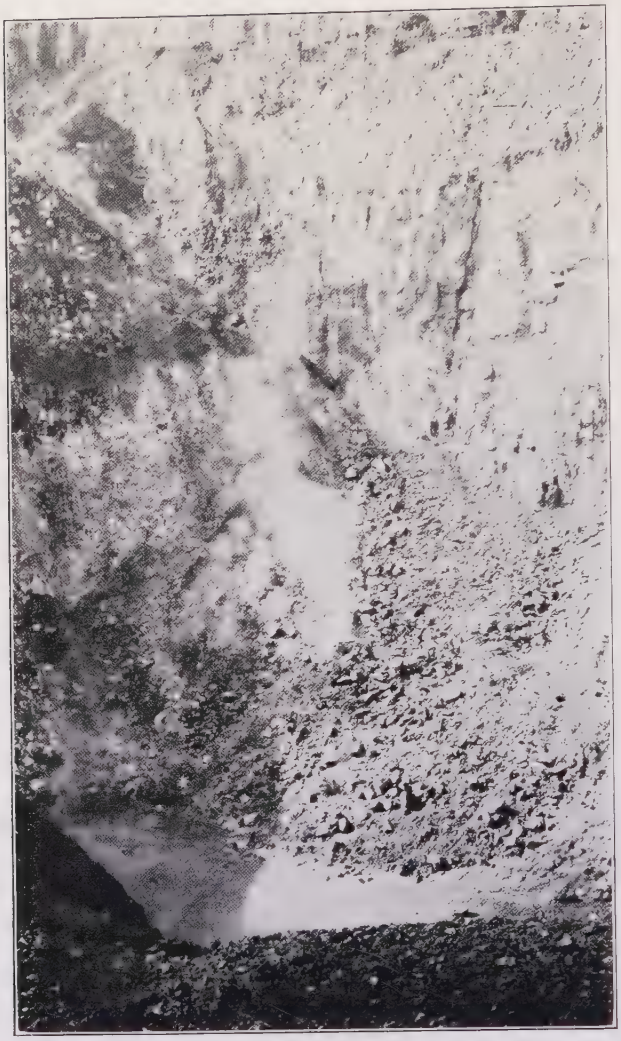
The *Myrsinaceae* are represented by small trees of the genera *Ardisia* and *Rapanea*. Both genera are absent in Hawaii, but two other genera take their place in these Islands, *Suttonia* and *Embelia*.

Sulphataras on Mt. Gedeh, near summit. Mt. Goenoengsela in the background.

Of *Apocynaceae,* Gedeh has one species of *Rauwolfia (javanica).* Hawaii has also one species, *R. sandwicensis,* but possesses other genera belonging to this family, as *Ochrosia, Alyxia* and *Pteralyxia.*

The *Gesneriaceae* are represented by nine shrubs, the majority of which are *Cyrtandra.* This latter genus possesses many endemic species in Hawaii.

The *Rubiaceae* are represented on Gedeh by 27 species, of which five are trees. None of the shrubby or arboreous genera occurring on Gedeh are found in Hawaii, but these Islands possess numerous endemic tree-species belonging to endemic genera. The only rubiaceous plant common to both Java and Hawaii is *Nertera depressa.*



The summit crater of Mt. Gedeh, looking down into the pit. Sulphur fumes and steam rise from the different sides of the crater walls. The crater is about 200 feet deep; the floor is dry mud.

The *Lobeliaceae,* so rich in Hawaii, are represented on Gedeh by three or four herbaceous species, belonging to *Pratia* and *Campanumoea.*

The *Compositae* are also sparingly represented. Of note is *Vernonia arborea,* a large tree, and *Anaphalis javanica* of the alpine region. The family is richly represented in Hawaii by many arborescent endemic species of American affinity.

Spacing Experiments with Sugar Cane.*

In the December, 1918, number of "The Philippine Agriculturist" are reported the results of a spacing experiment with sugar cane. In conducting this test one plot only was used for each treatment. This lessens the value of results to a large extent; nevertheless, we consider them of interest, and herewith give a brief resumé of the work.

A level field with a clay-loam soil from which a crop of corn had been harvested was used for the experiment. This area was divided in fifteen plots, each measuring 4837 square feet.

The following table gives the methods of planting, the number of seed used and the number of stools, three months after planting and at harvest time:

No. of Plot	Width of Row in Feet	Spacing of Seed in Inches	No. of Seed Used per Acre	No. of Stools per Acre, 3 Mos. After Planting	No. of Stools per Acre at Harvest
1	1.64	end to end	32,375	22,240	8,435
2 †	discarded	....	.....	.....	....
3	2.46	9.84	10,791	7,194	5,971
4	3.28	end to end	16,187	10,396	4,955
5	3.28	19.68	5,396	5,045	4,497
6	3.28	29.53	4,047	3,876	3,615
7	4.92	end to end	10,791	8,211	3,804
8	4.92	19.68	3,597	3,480	3,381
9	4.92	29.53	2,698	2,671	2,662
10	5.74	end to end	9,227	5,558	4,227
11	5.74	19.68	3,068	2,572	2,572
12	5.74	29.53	2,307	2,158	2,158
13	2.56	9.84	10,198	7,248	6,259
14	2.46	19.68	7,159	7,167	7,158
15	2.46	29.53	5,382	5,360	5,333

† Plot No. 2 discarded on account of poor germination.

* By Josi Mirasol Y. Jison in "The Philippine Agriculturist."

The yields per acre for each plot are given as follows:

No. of Plot	Width of Row in Feet	Spacing of Seed in Inches	Yield per Acre		
			Cane	Q. R.	Sugar
1	1.64	end to end	36.6	9.1	4.04
3	2.46	9.84	29.3	8.7	3.37
4	3.28	end to end	33.6	9.8	3.42
5	3.28	19.68	26.8	8.2	3.27
6	3.28	29.53	26.2	8.4	3.10
7	4.92	end to end	28.8	7.5	3.84
8	4.92	19.68	26.2	7.9	4.44
9	4.92	29.53	32.3	9.5	3.45
10	5.74	end to end	23.9	8.5	2.82
11	5.74	19.68	17.9	8.5	2.57
12	5.74	29.53	24.3	9.2	2.64
13	2.56	9.84	32.5	7.6	4.30
14	2.46	19.68	26.6	7.3	3.65
15	2.46	29.53	36.0	8.8	4.07

In plot 1 the furrows were made with a native plow because they were too close together to allow the use of a double mould board. All plots except plot 1 received the same treatment. After three months, plot 1 would allow no further cultivation, and weeding was done by hand.

The cane was planted March 10-16 and harvested when twelve months old.

The article concludes as follows:

Indications are that:

1. The percentage of success in germination is lowest in the thick planting and highest in the thin; the percentage of mortality of the canes between the age of two months and the time of harvest is higher in the former than in the latter.

2. When planted closely, the cane has poorer chance to sucker than when planted farther apart, consequently smaller stools are obtained in the first case, and larger ones in the second.

3. In general, when planted closely the cane tends to grow high, but small in diameter; but, when spaced widely, it tends to gain in diameter rather than in length.

4. The damage to cane fields caused by rats was found to reach 25% of the total weight of the cane.

5. The greatest yield in tons of cane per hectare was obtained from the plot where the canes were planted 1.64 feet apart, seed end to end. The greatest yield in tons of 96° sugar per hectare was obtained in the plot where they were planted in lines 4.92 feet apart and seed spread 19.68 inches.

6. It is recommended that canes in this locality be planted at a distance of 4.92 feet by 19.68 inches. Aside from giving the highest yield of sugar per hectare, this spacing would save seeds, labor and time, and would allow the greatest amount of cultivation without much injury to the roots of the plant as a whole. The gain per hectare of plot where the distance was used over that where the native method was employed (plot 13) is 0.32 ton of 96° sugar, which amount would sell, at the present price, for ninety pesos.

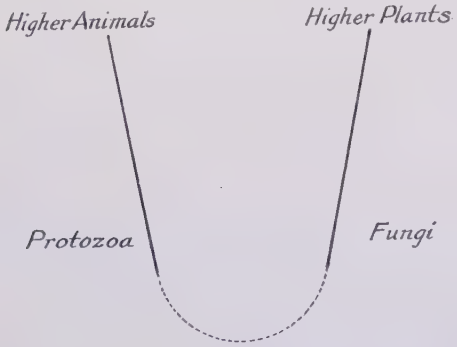
J. A. V.

Diseases of the Cane Plant.*

By E. L. Caum.

Disease in plants may be defined as variation from the normal physiological activity, which is sufficiently permanent to interfere with the plant's natural functions, and to check its development. The normal plant is in a state of equilibrium, based on the right amount of moisture, plant food, leaf surface to manufacture starch, etc. Anything which upsets this equilibrium will cause the condition which we know as disease. This upset may be due to one of three general causes—plant parasites, animal parasites, or adverse physical conditions. These talks will deal with the first class only—the diseases caused by plant parasites. The entomologists have covered the field of animal parasites, and the third class, that of physical conditions, takes in the whole field of fertilization, irrigation, cultivation, and the like.

To answer the question, "What is a plant parasite?" it is necessary to say something about the lower plants, or at least that group of them which we know technically as "fungi," and commonly as moulds, mildews, mushrooms, and the like. These plants, generally very small, differ from the higher plants, the trees, shrubs and the like, in that they do not possess chlorophyll. Lacking this chlorophyll, they are unable to elaborate their food from the raw materials, as the green plants do, and hence must obtain it ready-made. In this respect they resemble the animals, which likewise must get their food ready-made—in other words, steal it from some plant which has already manufactured it, or from some other animal. In the end, it goes back to the green plant as the original source of food for both animals and fungi. It should not be understood by this that the animals and the fungi are close relatives. They are not, except in a few cases, which I shall touch upon a little later. The fungi are the lowest forms of plant life, while the animals, or what we commonly know as animals, are well up the scale, on another branch.



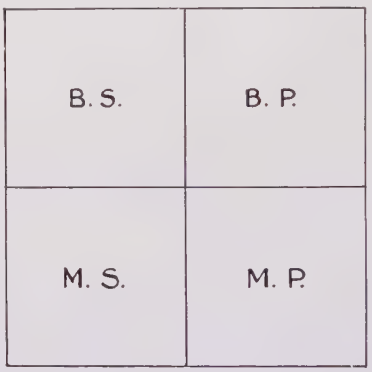
Fungi are divided into two great classes, based on their form and manner of growth. These are the bacteria and the so-called mycelial fungi. The bacteria are single cells—independent units of plant structure. They reproduce by simply dividing in two, each half then being a complete and independent individual. The mycelial fungi are multicellular—that is, they are composed of many cells—in this one respect resembling the higher plants. Their structure in a general way resembles a mass of threads, called the mycelium. This mycelium forms special structures, the fruiting bodies, and in these the spores, or reproduc-

* A series of lectures presented at the Short Course for Plantation Men, October, 1919.

tive bodies, are formed. These spores are comparable to, although not identical with, the seeds of the higher plants. The fruiting bodies differ greatly in size and structure in different species of fungi, just as the seed pods of the higher plants do. The spores are produced in great numbers. In one of the puff-balls there have been estimated to be as many as seven million million (7,000,000,000,000), and each one of these, given the proper conditions, should germinate and produce a plant like the parent. The individual plants of the fungi with which we have to deal do not produce spores in anything like this number, but still they are sufficiently numerous for all practical purposes.

Another great division of the whole group of fungi is based on their manner of obtaining food, or rather on the source from which it is obtained. These are the saprophytes and the parasites. There are intermediate stages, but we need not be concerned with them now. The saprophytes are those which feed upon dead or dying organic matter. They are the scavengers of the fungus world. The parasites, on the other hand, attack healthy plants or animals, and draw their sustenance directly from the living host. It is with this latter group that we have to deal—with the fungi represented by the last quarter of the square, so to speak. There are a few bacterial parasites of the sugar cane, but they are not numerous, and the fungus diseases affecting the cane in these Islands are practically all due to mycelial fungi.

As I said before, fungi must obtain their food ready-made, and from the cells of the host plant, in the case of the parasites, which are the ones with which we are chiefly concerned. This they do by the simple process of absorbing it, drawing the juices of the host plant through the cell walls and into their own bodies. Some parasites, which live on the outside of the host's body, and do not penetrate it, draw the juices through two cell walls, the wall of the host cell, and the wall of the fungus cell. Others simplify this process somewhat, by penetrating the body of the host, growing out between the cells and sending short branches directly into the host cells. This necessitates drawing the juices through only one cell wall, that of the fungus hypha, as the individual threads of the mycelium are called. Still others go this one better, and penetrate the cells of the host plant directly, living its life inside these cells, and not simply between them. These two classes are called external and internal parasites, or technically, ecto and endo-parasites. The important cane fungi are endo-parasites, the fungus penetrating the body of the cane plant.



B = Bacteria.
M = Mycelial fungi.
S = Saprophytes.
P = Parasites.

Fungi are often specialized in one way or another. Thus some kinds will grow only when the host plant was previously healthy, others only when it was weakened from some other cause. Some will grow on only one host, others will attack many kinds of plants. Mostly they are local; that is, they attack only one part of the host plant. Some attack only the leaves, others only the roots. Others are not so particular—they are found in various parts of their victims. Most of

the parasitic fungi are local, and this holds good with the sugar-cane fungi. We rarely find these fungi outside their particular part. Thus we find leaf fungi on the leaves only, and root fungi only on the roots.

The ways in which fungi can injure plants is limited only by the number of functions the plant has which can be interfered with. Thus some attack the leaves, destroying so many of the starch-manufacturing cells that the plant cannot complete its development; others destroy the roots or clog up the vessels, cutting off the supply of food from the soil; others destroy the flowers or fruits, preventing the formation of seeds; while others set up a rot in some vital part, such as the base of the stem, causing a general collapse of the whole above-ground part. There is no part of a plant secure from attack, and there is scarcely one of its functions that cannot be seriously impaired.

And now, before we start a discussion of the specific organisms that cause disease in cane, I want to make a little comment. There is no such thing as a magic cure or a quick relief for fungus diseases of the sugar cane. Many of the plantation people think there is, and that it is our duty to furnish it. It is our duty to provide relief, in so far as we can, but in any case it is a long job. There is nothing in the whole history of plant pathology the world over that justifies the belief in a swift cure. Of course, we have to know the cause of a disease before we can intelligently contrive measures against it, but the corrective measures when devised must of necessity be in the nature of modifications of our agricultural practices. As a recent bulletin (No. 721) of the United States Department of Agriculture expresses it, "All plant pathological problems, from a practical standpoint, are closely connected with the cultural phases of crop production. Production cannot be successfully studied without a knowledge of the diseases affecting that particular crop, nor can the diseases of a crop be intelligently considered with reference to control measures except in conjunction with the cultural practices, and with a knowledge of the conditions under which the crop is grown." And consider this other point. Human pathology is about 50% curative, and 50% preventive. Animal pathology is about 10% curative, and 90% preventive. Plant pathology, especially sugar-cane pathology, by the very nature of things, must be at least 99% preventive. Here is another little list that tends to show the same point, and the whole history of plant pathology has developed no other means of combating plant diseases than these:

1. Quarantine against diseased plants and disease-carrying materials;
2. Cutting out and burning of diseased parts;
3. Destruction of diseased individuals;
4. Elimination of intermediary hosts (barberry in wheat rust);
5. Application of fungicides to seeds, cuttings, etc.;
6. Sterilization of the soil;
7. Application of iron salts in some cases of chlorosis;
8. Fallowing of the land;
9. Rotation of crops;
10. Correction of unsanitary soil conditions;
11. Adjustment of agricultural practices (cultivation, fertilization and irrigation).
12. Employment of resistant varieties.

Of these, the last one is the most desirable, from a commercial viewpoint, provided the variety substituted is as good as the one replaced. If you will keep these points in mind, you will understand better what I have to say about the individual diseases.

We will deal only with those diseases which are found in Hawaii. There are many fungous diseases in other sugar-growing countries, but as they have not appeared in the Islands, we need not discuss them at this time.

The first group of these, as the most obvious, and the most commonly seen in the fields, are the diseases of the *cane leaf*.

(1) *Eye-Spot.*

This disease, along with several other leaf diseases, is commonly referred to as "rust." This name is descriptive enough, but misleading. There is a cane disease, very prevalent in Java, that is properly known as "rust." This is caused by a fungus related to those causing the various cereal rusts, and very different from any leaf-spot fungus we have here. The eye-spot fungus, Cercospora Sacchari, is of wide distribution, and has been found all over the Islands. It is of rather common occurrence, and as a general thing does comparatively little damage, except when it becomes epidemic. In bright, sunshiny weather it is practically harmless, but when the weather gets warm and moist it will spread with great rapidity, and do considerable damage to the cane. The disease occurs mostly in makai fields, because of the atmospheric conditions in such localities. It first appears as a small light green or yellow spot, showing on both sides of the leaf. This soon becomes brown or reddish in the center, and as the spot becomes older this red streak extends on out toward the end of the leaf. The stripes seem to follow the fibro-vascular bundles of the leaf. The fungus does not grow out along this stripe; it is found only in the original spot. The fungus apparently secretes some sort of a poison which, being carried along the vessels with the sap, kills the cells with which it comes in contact. It is in this habit that the danger from the fungus lies. Thus, one fungus plant, originating from a single spore, will kill a strip of leaf tissue clear from the point where it happened to strike the leaf to the end of the leaf.

As to control measures, there are none in the proper sense of the term. Spraying, of course, is out of the question, and the solution in this case, as in several others, lies in resistant varieties. As Mr. Agee said the other day, there is a difference between susceptible and sensitive varieties. Most of our cane varieties are susceptible to this disease, but they are not all equally sensitive. H 333, for instance, which was at one time considered one of the best of the Hawaiian seedlings, is extremely sensitive to eye-spot, and is frequently killed out by an attack that does hardly any damage to surrounding canes. Lahaina, H 109, Yellow Bamboo, and the Tip canes are also sensitive in varying degrees. D 1135, while susceptible, is not so sensitive, and Yellow Caledonia and H 146 are hardly susceptible at all. Neither is Badila. Young cane, as a rule, is more susceptible than the older plants. In one field here a year or so back, there was a mixed planting of H 146 and H 333. An epidemic of eye-spot struck the field, and after it had passed there was no trouble at all in picking out the H 146. The 333 wasn't there.

Non-resistance to eye-spot is an hereditary trait. A count made some years ago showed that 81 seedlings of H 333 were affected, while none of the seedlings of H 109, growing with them, were attacked at all severely.

In comparison with the many factors that affect the cane, the loss caused by eye-spot alone is very small, but even this loss may be largely overcome by planting resistant varieties like Yellow Caledonia, H 146 and D 1135 in places where epidemics are frequent.

(2) *Ring-Spot.*

This disease is caused by the fungus Leptosphaeria Sacchari. It resembles the early stages of the eye-spot disease, but differs from the later stages in that it does not form the characteristic red streaks on the leaves. Eye-spot kills a long strip of the leaf, while ring-spot kills only the small area where the fungus is growing. For this reason the damage is very slight, and the loss caused by the fungus may be disregarded. Our Hawaiian canes do not seem to be very sensitive to this disease, although most of them are susceptible. In the specimens of Badila leaves in the jar here, you can see that the spots are very numerous, yet the cane itself was apparently perfectly healthy, and was making a good stand. Taken all in all, ring-spot may be disregarded as the reason for any great losses in the sugar-producing powers of the cane plant.

(3) *Leaf Freckle.*

This is a rather mysterious disease. It is comparatively rare, and in spite of its looks, practically harmless. It has all the appearance of a fungus disease, but we have as yet been unable to isolate a fungus from the spots, and its cause therefore remains unknown.

(4) *Another Ring-Spot.*

This is a disease which has been found on both Hawaii and Kauai. It resembles the common ring-spot, but the spots are much larger. It is caused by a species of Leptosphaeria as yet undescribed. It is not likely that it will do any appreciable damage to the cane, both from its rarity, and from its relationship to the common ring-spot. It has been found on H 109 and Yellow Caledonia, and also on the "H 400" seedlings.

(5) *Another Ring-Spot.*

This disease is a new one, having been seen first only a couple weeks ago, and of course we cannot say anything about its possibilities for evil. There has not been opportunity to work up the fungus fully, but it appears to be a Leptosphaeria, similar to the one which causes the ring-spot disease. In appearance the disease resembles ring-spot somewhat, only on a larger scale. We cannot say anything yet about resistant varieties, beyond the statement that it has been found attacking both Badila and H 109 cane.

(6) *Pahala Blight.*

This disease does not properly belong in this list, but is here introduced because it is a rather conspicuous leaf disorder. It is characterized by distinct yellow or white stripes in the leaf, as can be seen from the color plate. It is

probably due to an adverse soil condition of some sort, although we are ignorant of just what this condition is. This disease was formerly ascribed to a parasitic fungus, but it has been shown since that the fungus is simply a saprophyte, living on the dead tissue of the leaf. The disease appears in winter, tending to disappear with the advent of warm weather. It attacks all varieties, and may be caused by soil conditions due to the volcano. It occurs in certain fields of one plantation.

(7) *Yellow Stripe.*

This is another leaf disorder that does not belong in this list, but is included because it is so common in the Islands. The cause is not known. The disease is characterized by a light green or yellowish mottling of the leaves, and in some varieties, notably Kokea, and to a lesser extent Lahaina, by a reddish streaking of the sticks. The losses caused by this disease are very great, although just how great is very difficult to determine. In Porto Rico, where the disease has only recently been recognized, the planters claim that unless a cure is found it will wipe out the cane industry of the island. In Hawaii the disease is not so virulent, but in experiments conducted here some years ago the loss in certain of the H varieties ran as high as 46½%. In one case, in Tip canes on homesteads on Hawaii, the loss in cane was estimated at 50%. This is, of course, pretty well above the average, but it tends to indicate that the disease is one that we cannot afford to neglect. In this case again we meet the question of susceptible and sensitive varieties. Nearly all our canes are susceptible. The Tip canes are very sensitive, while Striped Mexican is resistant. D 1135 comes about as near to being immune as any of them. H 109, while susceptible, is not very sensitive, according to the results of the experiments I just mentioned. Lahaina is both susceptible and sensitive. Yellow Caledonia and H 146 are both fairly resistant. The cure for this disease, or rather the method of overcoming it, lies in the selection of seed. Seed from Yellow Stripe sticks will almost invariably give rise to Yellow Stripe stools. In addition to this, experiments seem to show that the disease is infectious. While it is true that clean seed will occasionally give rise to diseased canes, a close selection for a few years should go far toward eradicating the disease. As I said before, the cause of the disease is unknown, and hence I cannot say what it is that injures the cane. The chances are, however, that the injury is pretty much mechanical; the mottling characteristic of the disease cuts down the leaf surface available for starch manufacture, and in that way impoverishes the cane.

(8) *Infectious Top-Rot.*

This is a disease which appears sporadically, and generally in a small patch. Its powers, however, are great, and it may kill off considerable cane if not checked in time. It is characterized by a rotting of the spindle and the growing point of the stick, which effectually puts an end to the life of that particular stick. This is accompanied by an odor which, once smelt, is never forgotten. The disease will spread fairly rapidly, and from its action, seems to be of bacterial origin. The particular organism causing it has not been isolated. The rotten tops, of course, are full of bacteria of many kinds, and it is probable that one of these, or several working together, will produce the disease. It

does not appear frequently, but when it does, the surest method of eradication is to cut out and burn the affected sticks. This will put a stop to the spread of the disease in that patch, and generally knock it out for the year at least. The disease is easily recognized in the field, the affected canes quickly dying and turning brown. They can easily be seen from a distance. This disease has great potentialities for harm, and in Mauritius, where it is only too well known, it is said to spread through the fields like wild-fire. The thing to do is to cut out and burn any affected sticks, and do it quickly.

Here are two other leaf troubles that look something like the work of parasitic fungi. The spots shown in the drawing are burns caused by nitrate of soda. The other is Tip Wither. If the cane is making a rank growth, and then a drought, or insufficient irrigation, coupled with high winds, comes along, the tips of the leaves will be dried out, giving the effect shown in the small colorplate.

This, I think, pretty well covers the group of the leaf fungi. The next in order, going down the stick, are those attacking the *leaf sheath*.

(1) *Iliau.*

This is an Hawaiian disease. It is our own product, but was reported from Louisiana in 1913. It was probably carried there in seed cane in times past.

The disease is as characteristic as the name is appropriate. The causative fungus, a soil-inhabiting form, attacks the young shoots before the lower leaf-sheaths are out of the ground. It grows into and around these sheaths, cementing them into a hard, firm case. This cementing is so well done that it is impossible to pull the sheaths from an iliaued stick without tearing them off in strips. Beside this, the sheaths are always pinkish brown in color, and the rind, if the shoot has succeeded in making any stick, is a peculiar bluish gray color. The danger from the disease lies in its faculty of cementing the sheaths together in what amounts to a straight-jacket. The young leaves in the spindle cannot force their way through this, and the stick is killed. The iliau fungus works best in cool, damp weather, and epidemics are to be expected in regions which have one or more months of such weather as a yearly occurrence. Occasionally the fungus will kill out the cane over considerable areas, but its usual practice is to take just one or two sticks in a stool, or occasionally an entire stool. It thrives best at the time when the cane is growing slowest, and many cases are known when the cane has been growing just a little too fast for the fungus. In these cases the cane grows away from the parasite, getting its spindle up to safety before the fungus can cement it in. There have been several measures recommended for the control of this disease. One is the careful removal and burning of iliaued shoots. The best one, however, is to give the cane a good start. Early planting, in regions where the disease is prevalent, will give the cane a chance to get its lower leaf sheaths out of the ground before the fungus weather sets in. The fungus can do no harm to the cane unless it can attack the sheaths. A thorough working over of the soil before the next crop is planted, in order to bring the spores to the surface, is also recommended. A very short exposure to the sunlight will kill the spores.

(2) *Red Spot of the Sheath.*

There are several causes of the red spots on the sheaths, one of which is probably a Cercospora, one of the eye-spot group. The damage done by this is so slight, though, that it may easily be disregarded. I mention it here simply for the sake of completeness.

(3) *Sheath-Rot.*

This is a disease discovered within the last couple years. At times it does considerable damage, but as a general rule it doesn't amount to much. The fungus, which has not been identified, attacks the sheaths, working inward until it reaches the spindle, which it proceeds to kill, thus effectually putting the shoot out of commission. This, like Iliau, works best when the cane is growing least, and good, healthy, rapidly-growing cane will soon grow away from it. In this fact lies the best method of overcoming the disease. Proper cultivation and fertilization will do the work.

(4) *Sclerotial Disease.*

This disease is caused by a very peculiar fungus. It is one of a group that cannot be properly classified, because to the best of our knowledge it forms no fruiting bodies. The threads of the mycelium simply knot up into small hard bodies, which serve to tide the fungus over unfavorable conditions. These, however, are simply resting stages, no spores being produced. For this reason the spread of the disease is very slow, and the areas attacked by it are usually small. The fungus is a sheath parasite, working in somewhat the same way as Iliau, by cementing the sheaths together. However, this cementing it not so tight, and the spindle, if not itself attacked, easily grows away from it. Where the spindle is not killed, the stick will make a normal growth, and experiments have shown that an attack by this fungus has no effect on the quality of the juices. The fungus is fairly easy to eradicate, because of the delicate character of the mycelium. A shallow plowing or two, in dry weather, will kill the mycelium. The sclerotia, the hard knots of mycelium formed as resting stages, are more resistant, and will last for some months, but if the mycelium is killed, the fungus will be effectually checked. It is not of any great importance anyway.

(5) *Phyllosticta.*

This is a parasitic fungus that has apparently been in the Islands for many years, but was only noticed about a year ago. It is characterized by small straw-colored spots on the lower part of the sheath, near the point of attachment to the stem. These spots, in some cases, extend downward onto the rind of the internode below. In some cases, notably in one of the seedlings at the Experiment Station, where the fungus was first noticed, the rind will be rather badly attacked. The cane does not seem to be set back any, though, even by bad attacks, and the disease may well be disregarded. It seems to attack all varieties of cane, and is pretty well distributed over Oahu, at least, and has been found on Maui. But in spite of this it is rare, and there does not seem to be any chance of its ever becoming a serious pest.

The next group of fungi to be considered are those attacking the cane stick. These are very few, in Hawaii, and unimportant.

(1) *Red-Rot.*

The first of these is the Red-rot, caused by the fungus Colletotrichum falcatum. It is weakly parasitic, and is what is known as a wound parasite, depending on an artificial opening of some kind to gain entrance to the interior of the stick. For this reason it does most of its damage to cuttings, where the cut ends offer a convenient point of attack. For this reason, also, it is often connected with attacks by borer and leafhopper. It lives on the sweet juice of the cutting, setting up a fermentation that kills the eye, preventing germination. This fungus caused some worry to the planters here a few years back, but we have heard nothing dangerous from it for several years. In case it does become active again, it is easily overcome by dipping the seed in Bordeaux mixture.

(2) *Pineapple Disease.*

Another parasite of the same type is the fungus which causes the so-called pineapple disease. This fungus, known as Theilaviopsis paradoxa, attacks cane cuttings in the same way that the Colletotrichum does, and in the early stages cannot be distinguished from it except by microscopical examination. As the fungus matures, though, it forms dense masses of black spores on the inside of the cutting, which turns the whole interior of the cutting black. This is another disease that has not been heard from lately, and apparently is not doing any great damage. It is present in the Islands, though, because it is a common fungus in the pineapple fields, causing the large straw-colored spots on the pineapple leaves.

(3) *Eye-Spot.*

This fungus, as I said before, is primarily a leaf parasite, but in one case at least has been known to attack the cane sticks. This exception is H 333. I said that this variety was extremely susceptible, and sensitive, to eye-spot—so susceptible that the fungus leaves its natural preserves, the leaf, and goes out into another region, which accounts for the serious results when an epidemic of eye-spot hits a field of H 333. After it passes, the H 333 very frequently isn't there.

(4) *Sereh.*

In this case, to put it mildly, we're up a tree. The sereh disease, as it is known in Java, is one of the worst, if not altogether the worst, cane disease known. It seems to attack nearly all the varieties grown there, and neither the cause nor the cure is known. The symptoms of the disease are well marked. The cane grows just so far, and then stops short, the leaves turn yellow, and the stick dies. This process is accompanied by an abnormal root growth, the dormant roots in the root-bands practically the whole way up the stick starting to grow. The fibro-vascular bundles in the nodes turn red, and the center of the stick becomes pithy. This pith is white and glistening, having a decidedly waxy appearance. The only way of overcoming the disease in Java is to plant what they call grandmother fields in the mountains, getting their seed from these fields to plant in the lowlands. Sereh is strictly a disease of the lowlands.

Sound seed from the uplands will last about three generations, when it, too, contracts the disease and becomes useless. Three generations means three plantings, all crops in Java being plant crops. Ratooning is not practiced. Clean seed must be planted, for the planting of sereh seed always gives rise to sereh cane. A disease has appeared in Hawaii, somewhat similar to this sereh, and which, for want of a better name, we are provisionally referring to as sereh. This disease shows the same stunted sticks, and the same abnormal root growth, but does not show the waxy center and the red bundles characteristic of the Java disease. Neither does seed of this cane give rise to diseased sticks. We have planted sticks pulled up when practically dead, and they have gone ahead and made a normal growth. Seed from diseased canes does the same thing. Hence, we are not in a position to say much about it. It looks like the Java sereh in some ways, and in other ways it does not. Neither does it act like it when diseased seed is planted. We have been working on this disease, but our results have not as yet shown us very much about it, and until we get more information as to the cause of the disease we cannot very well recommend a cure. It attacks both young and mature cane, and has been found on Yellow Caledonia, D 1135 and H 227.

The last part of the plant to be reached is the roots. The diseases affecting the cane roots are few, but, in the nature of the case, important. It is only natural that any disease which will attack and destroy the feeding organs of an important economic plant will be of great economic importance itself.

(1) *Root Disease.*

The first, and least, of these is the root fungus Marasmius Sacchari. This has been referred to as the Root-disease fungus, the stellate-crystal fungus, and other things. It is easily recognized, the fruiting bodies, which appear at the base of the sticks, being small and very delicate toadstools. These are not, however, to be confused with the small toadstools which are found on decaying trash, mud-press and the like after rains. If a Marasmius toadstool is found, the mycelium may be traced as shiny white threads through the tissues of the leaf sheaths and down into the roots. This fungus, while rather spectacular, was formerly credited with doing a lot more damage than it was really responsible for. There is not much to be feared from it if the cane is kept in a healthy, vigorously-growing condition.

It is a facultative parasite, attacking the roots and the underground parts of stems. It once appeared in virulent form. A trench two feet deep was dug around the infested area, and the area was covered with quicklime, and in a month or two furrowed out and replanted. The disease did not reappear.

(2) *Lahaina Disease.*

And last, but not by any means least, we come to the well-known Lahaina disease. In this case, while the disease itself is mysterious, its results are not, by any means. You are all undoubtedly familiar with the appearance of cane affected with this malady, and the samples here will help refresh your memories. This disease, under various names, has been known for many years in the different sugar-growing countries, and its cause is not yet known with absolute certainty. For a long time nothing was known of the disease beyond the

fact that something was killing the roots, with the resultant collapse of the plant. Various factors were discredited with being the cause—different soil conditions, different fungi, some animal parasites, and so on. Now just recently there have been two new theories offered. Mr. Carpenter, of the Federal Experiment Station, believes the disease is due to one of the mycelial fungi, a species of Pythium, which he finds associated with the disease. Dr. Lyon believes it is due to a very low form of fungus, one of the group that are on the border-line between the plants and the animals. They are a very peculiar group, and nearly all are parasitic on plants of one kind or another. Their status in the social scale may be judged when you know that the botanists claim they are plants, while the zoologists claim them as animals. They have some of the characteristics of both, yet not all of the characteristics of either. These plants (we might as well call them that for the sake of the argument) have the power of contracting themselves into round, heavy-walled resting spores or bodies, to tide themselves over unfavorable conditions, and it was the discovery of bodies of this sort in the living root-hairs of diseased cane that gave the clue. The Pythium also forms fruiting bodies that greatly resemble these resting bodies, and as far as they themselves go they might belong to either of these organisms. However, other organisms, or rather objects which appear to be other forms of Dr. Lyon's organism, have been seen, and these have no relation to the Pythium. Both organisms are found in roots of cane suffering from Lahaina disease, and it is possible that either of them, or both together, may cause the disease. These resting spores and the vegetative bodies belonging to them, are found inside the cells of the roots, and in the cases examined are quite sufficient to cause the collapse of the cane plants. We have several experiments under way at the present time, looking toward the control of the disease, but there has not as yet been sufficient time for them to show any results. The control measures advocated at present are the same as in the past—the planting of resistant varieties. We know that Lahaina is both very susceptible and very sensitive. So is H 146. Yellow Caledonia and Striped Mexican also are affected, while H 109 and D 1135 both show a high degree of resistance, as does Badila.

Finally, we might as well mention a few fungi, harmless in themselves, which have at different times been blamed for causing diseases in cane. The first of these are the stinkhorns. These fungi, purely saprophytic, were at one time named as the cause of root-rot. They are common in the cane fields, and frequently appear in lawns where a tree or plant of some kind has been cut down. There they are growing on the dead roots. In the cane fields they live on the decaying trash and other rotting organic matter. They are absolutely harmless to the cane.

The second, the so-called Rind Disease, is caused by a saprophytic fungus that attacks the dead cane sticks. It is characterized by the formation of black pustules on the sticks, which, under very favorable conditions, grow into long black hair-like structures. In the West Indies this fungus is said to attack healthy cane, killing it off, but in Hawaii it attacks only cane which has been killed by some other cause. It may be found on any piece of dead cane which is exposed for a little time. Sometimes, though rarely, it becomes a very weak parasite, attacking cane which, while still alive, is practically dead from some

other cause. As an active parasite, capable of causing losses in our cane fields, it is nil.

The third is the Sooty Mould. This fungus does cause an extremely slight loss in sugar, but its effect is purely mechanical. It is seen where leafhoppers or aphids are especially numerous, and, as Mr. Swezey told you before, its presence is an indication of the presence of these insects before they themselves are seen. These insects secrete a sweet substance known as honey-dew, which covers the leaves of the plant. This substance is sticky, and dirt and dust blowing about is caught and held. The black fungus favors this honey-dew, and grows luxuriantly upon it, thus, together with the dirt, causing the black, sooty appearance of the cane leaves where the insect pests are abundant. The fungus does not attack the leaves at all, but by covering them up it excludes the light, preventing the chlorophyll from functioning, and to a slight extent injuring the cane. The way to prevent the insignificant damage caused by the fungus is to get rid of the leafhoppers and the aphis.

Fourth—*Monilia sitophila.* This is the bright orange colored fungus that is often seen growing on mud-press in the fields, and on the fresh stumps after the cane is cut. It is feeding on the sugar there, but is absolutely unable to attack standing cane. It is not a cane parasite.

As to Hilling.

An interesting comment on Hilling in Java reaches us through Mr. W. v. H. Duker, who supplies us with the translation from the Java-Archief,* which we quote:

In connection with the hilling up, special attention should be given to keep young shoots separate instead of pressing them together; this applies to all cane varieties, and the more sensitive ones, such as G. Z. No. 100, more especially.

This is a very important point that in no case should be overlooked. As a rule the soil of both sides of the row is more or less pressed against the young and pliable cane stool. The consequence is that the upper roots of the shoots have only a very limited space for development on the inside of the cane stool, and only the roots at the periphery can reach their full growth.

When the precaution is already taken with the first hilling up to place a large lump of soil in the center of the cane stool, which prevents any pressing together of the young shoots, the growing stalks will take up an outwardly bent shape. The upper roots then have more space to take up plant food and the leaves become more free, giving the chlorophyl more benefit from the direct sunlight in the formation of starch.

H. P. A.

* 1919, Bul. 12, p. 753.

The Mosaic Disease of Sugar Cane and Other Grasses.†

By E. W. Brandes.*

History of the Disease.

The mosaic disease of sugar cane, the presence of which has recently been discovered in Louisiana and other Southern States, is the malady that in epidemic form has occasioned severe losses in parts of Porto Rico during the past four years. There it has been variously called matizado, "mottlings"; rayas amarillas, "yellow stripe"; morida de perro, "dog bite"; la enfermadad de Arecibo, "disease of Arecibo"; la enfermadad nueva, "new disease," etc. The disease was first noticed in Porto Rico about the middle of 1916.

Starting from some point near Arecibo, on the north coast of Porto Rico, it spread rapidly over the cane fields to the west, down the west coast to the south coast, and up into the valleys and hills of the interior throughout these regions. Its progress eastward was slower, but at the present time more than three-fourths of the cane fields of the island are invaded.

During the last 12 months, methods of control have been put into operation which have undoubtedly aided in checking the spread of the disease into new territory. It has appeared sporadically at a few points in the eastern fourth of the island, but the planters, thoroughly aroused and alert, have not permitted it to spread there as it has in the west. It has become the practice to inspect the fields regularly and eradicate diseased individual plants as they appear, thus removing the source of infectious material. This method has been successful where only a small percentage of the plants are infected. In the west, where 75 to 100 per cent of the plants in commercial fields are diseased, this method naturally can not be recommended. The average reduction in output of sugar for 10 mills in the worst infected area has been nearly 40 per cent, notwithstanding an increased acreage in cane, while the average output for 10 mills in the disease-free area shows a slight gain for the same period. These figures are approximate, but they indicate clearly the gravity of the situation.

The disease is not new, but was recognized as an undesirable condition in sugar cane as early as 1890 in Java, where it is called gele strepenziekte, "yellow stripe."[1] Owing to the failure of Dutch investigators to secure infection by artificial inoculation, they did not regard the disease as infectious, but rather as frequently recurring bud variations. This view was undoubtedly due to the fact that it had for years been present, but unnoticed and unrecorded as a specific disease, so that during this long period unconscious selection had eliminated all but the more or less resistant but not immune varieties of cane. Thus, where the disease had become endemic it would be especially injurious only to varieties imported from countries where the disease did not exist. It would be difficult to carry on

† United States Department of Agriculture, Bul. No. 829.

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[1] Wilbrink, G., and Ledeboer, F. Bydrage tot de kennis der gele strepenziekte. Meded. Proefstat. Java-Suikerindus., No. 39, 2, pp. 443-495, 5 pl. (4 col.), 1910.

successful infection experiments where the disease is as prevalent as it is in Java.

Dutch investigators reported the presence of yellow stripe in Egypt in 1909 on cane imported from Java and in the Hawaiian Islands in 1910. In the latter territory nearly all cane regions have become infested, and careful experiments have shown that where all plants in a field are attacked, according to Table 1, it causes a reduction in yield of sugar of 5 to 40 per cent, depending upon the variety of cane.

TABLE 1.—TESTS OF SUGAR CANE, SHOWING VARIETAL RESISTANCE TO THE YELLOW-STRIPE (MOSAIC) DISEASE IN THE HAWAIIAN ISLANDS.[1]

Variety [2]	Condition	Canes		Test of Juice			Requirement per Ton of Sugar		Loss Due to Disease
		No.	Ave. Wt.	Brix Scale	Sucrose	Purity	Wt. of Cane	No. of Canes	
Plant cane (18 months old):			Lbs.	Deg.	Pct.	Pct.	Tons		Pct.
H 227	Striped	60	4.10	18.5	16.7	90.3	7.81	3,810	18.05
	Healthy	212	5.17	18.0	16.2	90.0	8.07	3,122	
H 151	Striped	50	5.73	18.4	16.5	89.7	7.95	2,775	15.20
	Healthy	248	6.57	18.8	16.9	89.9	7.73	2,353	
H 135	Striped	50	5.69	17.3	15.7	90.8	8.29	2,914	15.97
	Healthy	292	6.96	17.2	15.4	89.5	8.52	2,448	
H 90	Striped	57	5.50	18.5	16.6	89.7	7.90	2,873	20.64
	Healthy	244	7.08	18.3	16.3	89.1	8.07	2,280	
H 69	Striped	38	4.50	18.7	16.6	88.8	7.92	3,520	26.09
	Healthy	265	6.12	18.8	16.6	88.0	7.96	2,606	
H 38	Striped	16	5.12	19.3	17.7	91.7	7.33	2,863	5.83
	Healthy	296	5.60	18.8	17.2	91.5	7.55	2,696	
H 27	Striped	39	8.03	19.1	17.1	89.5	7.67	1,910	10.16
	Healthy	172	9.16	18.7	16.7	89.3	7.86	1,716	
H 2	Striped	16	4.00	18.8	16.9	89.9	7.73	3,865	34.9
	Healthy	174	6.39	18.5	16.4	88.6	8.04	2,517	
H 197	Striped	34	6.34	19.0	17.1	90.0	7.64	2,410	6.06
	Healthy	154	6.90	18.8	16.8	89.4	7.81	2,264	
H 276	Striped	32	6.01	18.1	15.7	86.7	8.49	2,825	14.46
	Healthy	196	6.96	18.2	15.8	86.8	8.41	2,417	
H 291	Striped	79	4.05	20.0	18.1	90.5	7.21	3,561	19.7
	Healthy	185	5.10	19.8	17.9	90.4	7.29	2,859	
H 338	Striped	20	4.00	19.8	17.6	88.8	7.47	3,735	46.45
	Healthy	191	5.50	20.2	18.0	89.1	7.31	2,659	
H 339	Striped	15	4.03	16.7	14.5	86.8	9.17	4,551	27.76
	Healthy	126	5.25	17.7	15.4	87.0	8.63	3,288	
H 355	Striped	219	5.25	18.8	15.5	82.4	8.81	3,356	13.72
	Healthy	70	6.03	19.2	15.7	81.8	8.73	2,895	
First ratooned cane (11 months old):									
H 363	Striped	75	4.73	19.3	17.2	89.1	7.65	3,235	8.04
	Healthy	66	5.13	19.2	17.2	89.6	7.63	2,975	
H 197	Striped	58	2.80	19.9	18.2	91.5	7.13	5,090	24.63
	Healthy	310	3.60	20.3	18.7	92.1	6.91	3,840	
H 109	Striped	109	3.99	19.5	17.9	91.8	7.22	3,619	0.5
	Healthy	288	3.96	19.9	18.2	91.5	7.13	3,601	
H 69	Striped	84	3.50	19.0	16.7	87.9	7.91	4,520	14.76
	Healthy	213	4.08	19.1	16.8	88.0	7.86	3,853	
H 27	Striped	243	4.89	18.5	16.4	88.6	8.04	3,288	29.93
	Healthy	34	6.51	19.6	17.5	89.3	7.50	2,304	
Yellow Caledonia	Striped	16	2.56	19.7	17.8	90.4	7.33	5,727	26.1
	Healthy	372	3.66	19.1	17.0	89.0	7.74	4,229	
H 22	Striped	260	3.09	17.6	15.2	86.4	8.77	5,676	30.9
	Healthy	68	4.37	17.8	15.5	87.1	8.57	3,693	
H 20	Striped	24	4.10	19.3	17.3	89.6	7.08	3,454	11.97
	Healthy	345	4.73	19.9	18.1	91.0	7.19	3,040	

[1] Lyon, H. L. Losses due to yellow stripe disease. In Hawaiian Planters' Record, v. 6, No. 5, pp. 258-263, 1912. (Permission to use the data in this table was obtained from the editor of the Hawaiian Planters' Record.)

[2] H = Hawaii seedling.

Table 1 indicates clearly that the loss is due almost entirely to reduced tonnage. Diseased canes are uniformly much lighter than healthy canes of the same variety.

During the early part of the present year the mosaic disease was discovered by the writer at three different points in Cuba, apparently as the result of separate importations. At Cienfuegos it has been present for nearly 20 years, but as a result of their discarding diseased plants in the seedling and propagating fields because of their unthrifty appearance, and perhaps partly owing to the fact that a proper agent of transmission was not present or at least not abundant in this region, it has spread very little. At Santiago de las Vegas it was found on plants recently imported from Louisiana and from Tucuman, Argentina. The latter plants had come originally from Java. The disease had spread from these plants to an adjoining field of the native Crystalina cane. In view of this demonstration of its ability to spread at Santiago, it is very fortunate that the diseased plants were early observed and destroyed. A slight infection has been found at Mercedes, also as the result of a recent importation.

Infected cuttings have been received in both Porto Rico and Cuba from Tucuman, Argentina, but to what extent the disease is prevalent in Argentina has not been learned.

Last year the mosaic disease was found in abundance at La Romana and the city of Santo Domingo, Santo Domingo, and less plentifully at Samana, La Vega, Monte Cristi, and Bonao.[3] Lastly it was discovered at St. Croix, Virgin Islands, on cane imported from Porto Rico.[3]

Distribution in the United States.[4]

The presence of the mosaic disease in the United States was first suspected when an agent of the Office of Sugar-Plant Investigations of the United States Department of Agriculture discovered young diseased cane in Porto Rico from seed cane imported from Louisiana. The plants were so young at the time that secondary infection seemed improbable, and it was assumed that the seed pieces were diseased when shipped from Louisiana. Accordingly another agent of the same office visited Louisiana and on July 7, 1919, confirmed the presence of mosaic there. The State authorities were apprised of this important disclosure, and the Government agent made a hurried reconnoissance of the Gulf States, which revealed the fact that the disease was already quite widely distributed there.

On account of the infectious nature of the malady and the fact that it has caused severe losses in other cane countries, a complete survey of the Southern States was immediately instituted to determine the location of all infested areas and, if possible, to trace the original importation of the disease and the course of its subsequent spread. Infested areas have been well delimited. The disease has been found by inspectors of the United States Department of Agriculture in Louisiana, Florida, Georgia, Alabama, and Mississippi (Fig. 1). It is most abundant in Louisiana, as would be expected. There the river district is already badly infested. As far north as Angola, in West Feliciana Parish, several fields

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[3] Stevenson, John A. The mottling disease of sugar cane. In Jour. Dept. Agr. and Labor, Porto Rico (in press).

[4] Thanks are due to Mr. W. G. Taggart, vice director of the University of Louisiana Sugar Cane Experiment Station, and to Dr. C. W. Edgerton, pathologist, Louisiana Experiment Station, for courtesies extended to the writer and suggestions facilitating the survey in Louisiana.

in a large plantation were found in which 75 per cent or more of the plants had the mosaic disease. From this point south to Donaldsonville, however, the amount of infection is not heavy. Many plantations are entirely free from mosaic, so far as can be determined by inspection. From Donaldsonville to New Orleans an increasing amount of infection was recorded by the inspectors. Between Lutcher and Reserve, about 75 per cent of the plants in every plantation were infected. This is by far the most heavily infested large area in the United States. From this region to New Orleans and from New Orleans to the lower extremity of the river district the amount of infection ranges from 4 to 30 per cent. Just a few fields were visited where no mosaic was found.

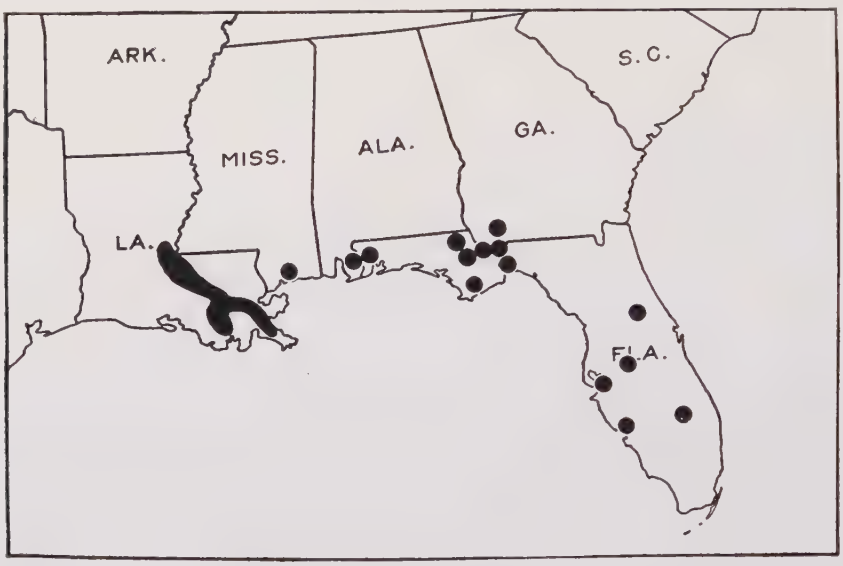

Fig. 1. Map showing the location of diseased areas of sugar cane in the United States.

In the Bayou Lafourche district mosaic was found in only about one out of four fields visited, and where present amounted to only 1 to 8 per cent of the plants. In the Bayou Teche district no mosaic was found on plantation cane, although nearly 500 fields were carefully inspected. A few cases were found in this region on cane recently distributed by the State Sugar Experiment Station. The immediate destruction of these few sources of infection is a matter of great importance. No mosaic whatever was found west of Bayou Teche or in Avoyelles and Rapides Parishes to the north. Thus, a very considerable part of the sugar-cane lands of Louisiana is still free from the disease, and every effort should be made to keep it free.

In Georgia the worst infested region is in the vicinity of Cairo, Grady County. There the proportion of infection ranges from less than 1 to 75 per cent or more in fields where the disease is present, but only about one-fourth of the cane fields in this county harbor the infection at all. The affected area is quite sharply delimited, all of the disease being confined at present to farms located on the highways leading out from Cairo. The cane fields in Georgia consist usually of a few acres grown for sirup making. It is quite possible that

by prompt and energetic action this community could free itself from the mosaic disease in short order.

Cane fields are distributed over practically the whole State of Florida, but the crop is grown largely for sirup for home use and the cane patches are even smaller than those in Georgia. Mosaic has been widely scattered over the State by the distribution of cuttings from experimental plats grown for the purpose of testing varieties. There are only two points, however, where the disease has spread so as to include any considerable area, namely, the vicinities of Marianna and Bristol. Other points in Florida where mosaic has been found include Apalachicola, Tallahassee, Punta Gorda, Palmetto, De Land, Winterhaven, Chattahoochee, Muscogee, and Canal Point. These are all purely local infections, and in some cases the disease has not yet spread more than a few rods from the original plantings shipped in from other States. An eradication campaign would be entirely practicable in Florida.

Mosaic has been discovered at only one point, Biloxi, in Mississippi. From the farm on which it first appeared it spread to one other farm in the vicinity.

In Alabama similarly, it was found only on one place, near Muscogee, Fla. It was confined to the farm where it first appeared.

Final reports on the results of the inspection in Texas must be deferred, since the survey is still under way in that State.

The survey has also been very illuminating concerning the probable time of introduction of the disease into this country and the method of its subsequent spread here. Since 1913 a prohibitory regulation has been placed upon the introduction of sugar cane into the continental United States, and it is probable that no cane has been introduced since that time. Prior to 1913 varieties of sugar cane were imported many times by private individuals and by various Government agencies. The Sugar Experiment Station of the Louisiana State University, at Audubon Park, has been particularly active in importing new varieties, with the idea of securing some higher in sugar content and yield than those already grown here. Whether the mosaic was introduced by the experiment station or by private individuals, no particular blame attaches to those who are responsible for the importation of this obscure disease. There is no known method by which the presence of the disease in cuttings can be positively established. It is merely pointed out that such an importation would be practically impossible with the present quarantine against sugar cane. Concerning the probable time of the importation that was responsible for the present wide distribution of mosaic in America, the survey has brought out the fact that the distribution of cuttings by the Louisiana Sugar Experiment Station in 1914 and prior to that time has not resulted in establishing the disease at the points where such cane was received. Since 1914, however, every point receiving seed from the station has become the center of a larger or smaller infected area. The inference, of course, is that while the disease may have been present at the station for a few years prior to 1914, it had not become so widespread that every seed shipment from there contained some infected cuttings. At the present time, about 97 per cent of the cane plants at the station have the mosaic disease. It is probable that private individuals have imported cane with this disease, but

such cane is not likely to be widely distributed, and its spread, therefore, must depend upon natural agencies, a much slower process.

Without exception, every infested area in Georgia and Florida can be directly traced to distributions of seed cane from the Sirup Field Station at Cairo, Ga., since 1916, and the infection at this station dates from the importation of a number of varieties from Audubon Park in 1915. In nearly every instance where diseased cuttings have been received from Cairo, it has resulted in secondary infection of the surrounding native cane.

The above is the brief and much condensed compendium of a large amount of data collected during July, August, and September, 1919. It has made possible the recommendation of plans of attack upon the mosaic disease, which vary slightly in the different cane regions of the country, but all of which, if strictly adhered to by every cane planter, will bring the disease under control. Its capacity for rapid spread, as demonstrated in Georgia and Florida, means that a lapse of one year will result in immeasurably complicating the problem of ultimate eradication.

Losses in the United States.

Since the mosaic disease had been unrecognized in this country until the writer announced its presence in July of this year, no extensive data have been accumulated to determine whether the losses caused by it in the United States are comparable with those sustained in Porto Rico. A few figures (Table 2) have been obtained in Louisiana, however, which indicate that we may expect a decrease in yield almost equal to that in Porto Rico if the disease is permitted to become as widespread here as it is in that country. Losses here are held in check somewhat on account of frequent replanting. It has been noticed that where infected sugar cane is allowed to ratoon over a long period of years that losses due to the mosaic are more severe each successive year. The figures in Table 2 were obtained by cutting all of the cane in approximately square patches of about one-tenth to one-fifth of an acre selected in commercial fields and in the fields at the Sugar Experiment Station, Audubon Park, La. The stalks cut from such patches were then sorted into two classes, diseased and healthy, and the average weight of stalks in each class was determined. The patches were not selected at random, but an attempt was made to find areas where the mosaic was doing a maximum amount of damage and at the same time a sufficient number of healthy plants were present in the patches, growing under identical conditions, in order to make a fair comparison possible. Since, if no attempt is made to control the disease in these fields, we may expect ultimately to find an infection of 100 per cent, the losses will then be equivalent to the figures found in column 5 of Table 2.

TABLE 2.—TESTS OF SUGAR CANE IN LOUISIANA, SHOWING THE EXTENT OF LOSSES IN DIFFERENT VARIETIES.

Variety	Number of Stalks		Average Weight of Stalks		Reduction in Weight of Diseased Stalks	Diseased Stalks in Field	Loss in Tonnage
	Healthy	Diseased	Healthy	Diseased			
			Pounds	Pounds	Pct.	Pct.	Pct.
Louisiana Purple	330	160	1.13	0.7	38	32	12.16
Louisiana Striped	268	100	1.507	1.22	19	27	5.13
D 74	204	108	1.27	1.03	18	34	6.12
D 95	348	136	1.65	1.16	29	28	8.12
L 511	373	310	0.874	0.787	10	45	4.5

Primary Symptoms.

Upon walking between the rows of cane in an affected field, more or less plants will be seen that are conspicuous on account of a general pallor of the leaves. This may be discernible for many rods. Closer examination of such plants reveals that the pallor is due to irregular light-colored streaks or spots on the leaves. The affected leaf areas, in so far as color is concerned, are of two distinct types. The most common type presents merely a "washed-out" appearance. It is, in fact, merely a tint of the normal color, in which the blue and yellow are present in the same proportions but diluted. In the second type, the yellow is predominant, and the affected areas have a decidedly yellowish green appearance. The normal and affected areas are sharply demarked. In other words, there is no gradual merging of one color into the other. There is a great diversity of patterns in the different varieties, due to the variation in the amount, size, and shape of the light-colored areas, but the arrangement is so constant in any particular kind of cane that the character could be used as an aid in determining varieties.

Among the cane varieties commonly grown in Louisiana and other Southern States, some rather constant differences occur in the expression of the mosaic disease. In L 511 it will be noticed that streaks are rather scant in newly-invaded leaves and on account of their light color make a great contrast with the normal areas. They are bluntly pointed and range from one-sixteenth to three-sixteenths of an inch wide and from one-fourth of an inch to 3 or 4 inches long (Pl. I, Fig. 4). Later, the light areas or streaks are more numerous and in most cases tend to become confluent in well-defined bands of light tissue extending across the leaf at right angles to the midrib and alternating with bands where the light streaks remain isolated. These bands are from 1½ to 2 inches long. The above condition is typical of the disease as it appears in L 511, but does not invariably occur.

In D 74 the streaks are not usually isolated, even at first, so that very quickly the coalesced light areas are predominant and the normal areas appear as irregular, elongated islands 1 thirty-second to three-eighths of an inch wide and of varying length, from one-fourth of an inch to several inches, as shown in Plate I, Fig. 5.

Affected areas are light green at first, but the tendency for the whole leaf to become opaque yellow is pronounced.

In purple cane the light areas are elongated and isolated at first, but later they predominate and coalesce and the normal green shows as irregular elongated islands, as illustrated in Plate I, Fig. 5. The islands are not of uniform width or length.

In the youngest leaves of Ribbon cane, the light areas are in the shape of attenuated streaks, usually about one-eighth of an inch wide and one-half of an inch to 1½ inches long, but the size varies greatly, some streaks being very minute, and others, by running together at the ends, form continuous stripes 6 inches or more in length. In general, the streaks are isolated from one another and uniformly distributed on the leaf blade as in Plate I, Fig. 4. The amount of normal-colored tissue greatly exceeds the light tissue at this time. Exceptionally, the light streaks may be confluent from the first, and this is more frequently seen near the midrib, leaving the margin normal in color or with a few scattered pale streaks. In slightly older leaves, by growth and confluence of the light-colored areas the latter becomes predominant and the whole leaf becomes pallid or even yellow in its general appearance. The dark-green or normal areas are now very scant, and they appear as elongated streaks in the pale green, just the reverse of the condition in young leaves, except that the dark-green streaks are less regular in outline. The individual streaks vary considerably in width and direction throughout their extent, streaks perhaps three-eighths of an inch wide at one end becoming constricted to 1 thirty-second of an inch, then alternately widening and narrowing or becoming oblique with the midrib, with no apparent forces limiting their extent or direction except that in general they are elongated in the direction of the parallel veins of the leaf.

In D 95 the light areas are predominant from the start (Pl. I, Fig. 5).

In L 219 the light streaks are isolated near the base of the leaf, but become confluent toward the tip.

In L 226 the streaks are isolated and even in older leaves remain so.

L 231 is very severely injured. The leaves are usually quite yellow, as shown in Plate I, Fig. 6. Practically the entire surface is light from the beginning. There are exceptions, however. The amount of injury in this variety is variable.

L 253 is quite tolerant. The lighter areas predominate, but are not yellowish. All plants seen were dark green and vigorous.

Secondary Symptoms.

Field observations covering a number of years indicate that the deleterious effects of the mosaic disease are cumulative. The streaking and spotting of the leaves discussed above are the only noticeable signs in newly-infected plants. The disease is never fatal during the first year and, in fact, it rarely terminates in death even in diseased plants that have been allowed to ratoon for years. Usually, however, more serious effects are seen in first ratoons of cane which became infected the previous year or in plant cane originating from diseased cuttings. At this time another quite distinct leaf symptom appears. It consists of small white opaque spots and streaks in the light-colored areas. These streaks are smaller than the light areas previously mentioned, and differ from them in having no

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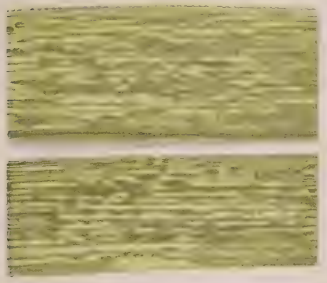
BUREAU OF PLANT INDUSTRY

1—A short piece of healthy leaf of the immune variety Kavangire.

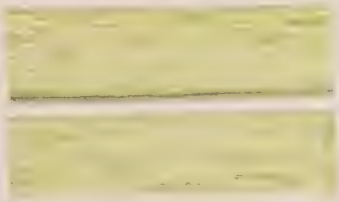


2—A piece of leaf of variety B 3922, showing isolated, more or less rounded and irregular patches of normal color on a background of pallid, affected tissue.

3—A piece of leaf of variety D 117, showing a mosaic pattern somewhat similar to the above but finer.

4—A common type of mosaic: irregular streaks of pallid green of unequal length and width but orientated in the direction of the long axis of the leaf on a background of normal green, on leaf of variety Rayada.

5—A pattern somewhat similar to the above, the colors reversed so that the pallid green predominates, on leaf of variety C. C. 1474.



6—The most injurious of the common types of mosaic: just a few streaks or bands of normal green tissue on a background of yellowish green, on leaf of variety M 134.

pigment whatever. They range from mere points to elongated irregular streaks several inches in length. The white streaks may become confluent to a limited extent. They are for the most part restricted to the light-green areas of affected leaves, but do not correspond to them in outline and typically remain more or less isolated from one another. The white opaque tissue has a dried-out appearance and seems to be quite functionless. It remains firm, however, and does not become brown or rot out. The amount of total leaf area occupied by this type of tissue rarely exceeds 20 to 30 per cent of the whole.

At about the same time, or during the next year, a still more injurious sign of mosaic appears, namely, the striping or cankering of the stalk. This is much more marked in some varieties than in others. Ordinarily, it does not become noticeable until the cane is quite well developed. By tearing away the enveloping leaf bases, cankers can sometimes be found in the incipient stage. They appear as discolored or water-soaked patches or longitudinal streaks on the internodes. In severe cases these areas become sunken and the internodes are spindle-shaped and attenuated. Longitudinal cracks may appear, resulting in the drying out of the cane. There is a tendency toward shortening of the joints and premature development of roots and shoots at the nodes of standing cane. Figure 2 shows such a condition in Yellow Caledonia cane. The photograph reproduced here was taken at Arecibo, Porto Rico, in 1919, and the probabilities are that the plant had been infected for at least five years. These identical cuttings and similar ones were brought to Washington and planted in a quarantine greenhouse. Most of them grew, but at the present time, five months after planting, they are scarcely 1 foot tall. The opaque white streaking covers practically all of the leaf area. This is the most excessive injury ever observed by the writer. Most varieties of cane do not go to pieces like this, but rather the injury to stalks consists merely of retarded development. Among the well-known varieties, however, all gradations in the extent of injury between these two extremes are to be found.

When a large proportion of the plants in a field are infested, the aspect in general resembles the effect of a severe drought. The foliage of the entire field is yellowish, and the plants are more or less noticeably stunted. Where a row of some immune variety is planted in or near a badly infested field, the contrast in color is exceedingly conspicuous and the dwarfed habit of infected plants is more noticeable. It is possible to recognize such fields from a distance of half a mile or more on account of their sickly, dry appearance.

Injuries Resembling Mosaic.

Many types of injury are commonly found on cane leaves that might be confused with this malady by one not familiar with it. The condition termed chlorosis, which is due for the most part to soil conditions, expresses itself in many ways, some of which closely simulate the mosaic disease. The affected areas are white opaque or yellow, and the most familiar form is a regular striping of the leaves longitudinally. The stripes usually extend the entire length of the leaves and may be about one-eighth of an inch wide and numerous, with normal green stripes of equal width spaced between them, or the chlorotic areas may be quite wide. Occasionally, the entire leaf is pure white. Less frequently the areas are in the form of large spots or blotches, extending inward

Fig. 2. Canker stage in Yellow Caledonia sugar cane; healthy cane of the same variety in center.

from the margins of leaves or situated at the center of the blades anywhere from base to tip. Another type, which is rare, consists of a very fine irregular white mottling of the leaves, which, however, is in local patches and does not involve the whole leaf, as is invariably the case with the mosaic disease. Many fungi cause spotting of the leaves of cane, but these can easily be distinguished, as the spots usually turn brown and the leaf tissue dies, which does not occur in the cane mosaic. Since a pale-green halo is sometimes present surrounding these small spots, they have the appearance of mosaic from a distance, especially when quite numerous, but a close examination always reveals quite distinct differences. Many insects, especially those which feed by puncturing the leaf epidermis and sucking the sap from the layers of cells below, cause a very fine mottling of the leaves when the punctures are present in enormous numbers. Ordinarily, the punctures are scattered and can lead to no confusion. This type of injury can also be determined by close inspection, since the minute pale area surrounding each individual puncture is almost exactly circular and has no tendency to elongation in the direction of the long axis of the leaf, such as is almost invariably the case in true mosaic. Drought, lack of proper nutrients in the soil, excessive rainfall, and poor tilth, or combinations of these, sometimes result in a general pallor or yellowing of the leaves, but this color is always uniform and can lead to no confusion.

Varietal Susceptibility.

varieties attacked.

More than a thousand varieties of cane have been determined to be susceptible to the mosaic disease. Most of these are the progeny of seedling canes that exist in small variety-test rows or patches at the various sugar-cane experiment stations, but the list includes also practically all of the commercially esteemed sorts grown for the mills on a plantation scale.

So far as can be learned, none of the varieties grown in Java is truly immune, but a high degree of resistance or tolerance of the disease has been observed in the favorite Java seedling canes grown in Porto Rico, a probable explanation of which has already been given. Only Java 56, 100, 228, and 234 have been seen by the writer in Porto Rico, but all of these, though 100 per cent of the individuals were affected, made a thrifty growth and produced apparently normal stalks. The leaves are not noticeably yellowed, but, on the contrary, appear to be of uniform dark-green color when viewed from a distance. Close inspection, however, shows the characteristic streaks, but the diseased areas are very little lighter than the normal areas. Probably the damage done to an individual plant is slight, but the aggregate damage to all of the individuals in a field is a measurable quantity and has been shown to be quite considerable in Java. In the different varieties all degrees of tolerance are exhibited, ranging from the highly resistant Java canes down to the soft white Otaheite or Bourbon cane, which is so severely injured that the cane is hardly worth milling. In addition to the conditions which might be termed varietal tolerance of the disease, some varieties exhibit decided and rather constant differences in the percentage of individuals that become affected under the same conditions. This is brought out in variety-row tests where the same varieties have been planted at several

points in the same field. Under these conditions it has been found that some varieties will show a 100 per cent infection of the individuals in all of the rows, while in others perhaps only 60 per cent of the plants will be diseased in each of the separated rows or plats. It seems reasonable to suppose that all varieties were equally exposed to the contagion in such situations. This fact indicates a possibility of resistant strains among the individuals of a variety.

The Rayada or Striped cane and the Crystalina or White Transparent, the two favorite varieties in Porto Rico, are severely injured. Yellow Caledonia is grown on a large scale in some localities, and plants of this variety killed by the mosaic disease have been observed. This is quite unusual, since attacked plants of most varieties become badly stunted but do not die. All seedling canes from Demerara and Barbados grown in Porto Rico are attacked. Seedlings of the Insular and Federal agricultural experiment stations likewise are all affected, as are the seedlings originated at Centrals Guanica and Fajardo. Among the varieties planted commercially, to a limited extent the Bambu, Cavengerie, Morada, and, in fact, all the broad-leaved canes have proved to be susceptible.

In Cuba all varieties that are exposed seem to become infected, but since the disease has not become rampant nor spread over any considerable area, no opportunity to observe the reaction of all the varieties grown there is to be had. Practically all of the seedlings originated in the Harvard Experiment Station near Cienfuegos were affected, as well as the imported Java 228, L 511, and the native Crystalina at Santiago de las Vegas.

Practically all varieties are attacked in the Hawaiian Islands, and extensive damage is done.

The common varieties in Louisiana have proved susceptible to mosaic disease. Louisiana Purple, Louisiana Striped, D 74, D 95, L 511, L 218, L 219, L 226, L 231, L 253, and hundreds of seedlings being tested at the Louisiana Sugar Experiment Station all fall prey to the ravages of this disease.

IMMUNE VARIETIES.

Fortunately a few varieties of sugar cane have been discovered which appear to be entirely immune. Most of them are of the slender North India type, generally known as Japanese canes. The Kavangire, a variety which, because of its prolific stooling, yields a very large tonnage and is much esteemed in Argentina for making sugar, has never been observed to be diseased, although it has been exposed to infection for four years in the worst infested regions of Porto Rico.[1] It is a rather long season cane, however, and for this reason is probably not suited to Louisiana conditions. Another Japanese cane, Cayana 10, which is becoming prominent in the sirup sections of Georgia and Florida, is also immune. This variety has already met with considerable favor on the part of cane growers in Georgia. All the other Japanese varieties observed, including many imported by the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, have been found to be uniformly free from this disease.

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[1] Townsend, C. O. An immune variety of cane. (Abstract of an article by F. S. Earle.) In Science, n. s., v. 49, no. 1272, pp. 470-472. 1919.

Among the broad-leaved thicker stalked varieties several kinds have been found that appear to be immune, but our evidence of their immunity is not so complete as is the case with the Japanese varieties. Louisiana seedlings 1646, 1606, 1674, and 1797, growing in the variety test plats at Audubon Park, New Orleans, this year appeared to be immune. No individuals of these varieties were diseased, although they were surrounded by other varieties, the individuals of which averaged 97 per cent diseased.

Other Hosts.

A number of other grass plants are known to be subject to the mosaic disease, but apparently they are attacked with difficulty and only under conditions favorable to the disease. Among these hosts are corn, sorghum, rice, millet, crab-grass, foxtail, and Panicum. Probably the list of susceptible plants is much larger, but up to the present time opportunity for testing others has not been had. In the case of corn, rice, and millet, we have no experimental proof that the diseases are the same, but must depend upon field observations. If not the same, the disease must be very similar, since the leaf symptoms are identical. The characteristic streaked and spotted appearance of the leaves is present in all attacked plants.

With regard to sorghum, crab-grass, foxtail, and Panicum, our evidence is conclusive and proves that the infectious material or virus is the same for all of these plants. Sorghum seed of the Early Amber, Sugar Drip, and Japanese Ribbon varieties was sown in a bed at the quarantine greenhouse at Washington, where diseased plants of 17 different varieties of sugar cane were growing. When the sorghum plants were about half grown, practically all of them began to produce mottled leaves and continued to do so until they went to seed.

The seed was saved from these sorghum plants to determine whether the disease is transmitted to the next generation in the true seed.[2] The leaf symptoms in these greenhouse plants were exactly like the symptoms on sugar-cane leaves. Plants arising from the same batch of seed used in the greenhouse experiment cited above but planted elsewhere and not exposed to the disease did not show the phenomenon, but produced healthy leaves of uniform color. The crab-grass, foxtail, and Panicum came up as volunteer plants in the quarantine greenhouse. Scores of stools of these weeds were allowed to mature for observation and identification. Every plant became infected and exhibited the typical leaf symptoms. Some half dozen other species of wild grasses were present in the greenhouse, but they were not attacked. All of the wild grasses were abundant outside of the greenhouse, but in spite of an assiduous search in the vicinity not a single infected plant could be found. The conclusion to be drawn from these observations is obvious. We are not dealing with similar mosaic diseases of these various graminicolous hosts, the viruses of which are specific for each host, but with one and the same disease.

The existence of other host plants, especially the common wild grasses, would appear to be one of the most alarming of the recent developments in the problem. It is needless to say that the control of the disease would be immeas-

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2 This seed was planted in flats. At the present time, three weeks after germination, no sign of the mosaic has appeared.

urably complicated if it were to become prevalent on such omnipresent weeds. Fortunately, however, our observations appear to indicate that the grasses other than cane become infected only under conditions favorable to the disease and in the near vicinity of infected sugar-cane plants. Infected corn, for instance, has been seen by the writer only in Porto Rico, where it was growing between the rows of diseased cane stubble. Infected rice plants were observed there only once, growing just across a narrow dirt road from a badly attacked cane field. At Audubon Park, La., attacked sorghum was seen in the similar situation, the most remote plants being only about 3 rods from the cane, and the percentage of attacked plants decreased in an inverse ratio to the distance from the cane. The same was true of crab-grass, which was abundant in the sorghum field. These observations are encouraging and tend to offset the disconcerting facts discussed above.

Nature of the Disease.

infection phenomena.

Sugar-cane mosaic is an infectious chlorosis, similar in many respects to the mosaic diseases of tobacco, cucumber, bean, tomato, and potato. Evidence of its infectious nature exists in hundreds of field observations and in the infection of experimental plants under controlled conditions. The well-defined epidemic in Porto Rico, in which it has been established that the disease started in a small local area and gradually spread from this focus of infection, diseased plants being confined within the limits of the ever-increasing infested territory and not appearing sporadically at remote points, is convincing. It leads to the inevitable conclusion that some virus or inoculum is responsible for the appearance of new cases and that the only source of inoculum is some plant previously infected with the disease. No other explanation accounts satisfactorily for the observed facts. Climatic conditions were at first suggested, but the epidemic has lasted already for a period of years, during which rainfall, temperature, sunshine, and the other factors that go to make up climate have been normal. The wearing out of soils was regarded as a possible cause, but during the steady progress of the disease it gradually encroached upon every conceivable type of soil, including the richest and most productive in the island. Strong support was given to the idea that it was a case of deterioration or the "running out" of varieties, but when it became evident that all varieties present in the invaded district were affected, this idea was abandoned. For the same reason the hypothesis that it is a case of bud variations, or "sports," seems highly improbable, and when the regular progress of the epidemic is borne in mind, radiating outward as it does from a common starting point, there is seen to be nothing to substantiate this claim.

Only a few specific observations of infection may be cited in the limited space available. In October, 1918, healthy seed of about 80 varieties was brought into the infested area from disease-free regions in order to determine whether any natural immunity existed among the varieties present in Porto Rico. This seed was planted at the Santa Rita estate, near Yauco. When the seed germinated, the young plants were seen to be healthy and normal, but within six weeks to two months practically every plant of all varieties with one excep-

tion (the Japanese Kavangire) showed the unmistakable symptoms of mosaic. This was a clear case of secondary infection from the fields of diseased cane surrounding the test plat.

At Santiago de las Vegas, Cuba, about 200 seed pieces of Java 228 cane imported from Tucuman, Argentina, were planted in two rows, and two rows of the native Crystalina cane were planted beside them. The Java cane was 100 per cent infected when it came up, the cuttings having come from diseased parent plants. When this planting was examined in June, 1919, 75 per cent of the Crystalina plants were characteristically diseased. The Crystalina seed pieces had come from a field which was minutely searched and found to be entirely free from disease. No other cases were found in the entire region, in fact, with the exception of a single stool of L 511 imported from Louisiana.

In July, 1919, a field of D 74 stubble cane, grown for sirup near Cairo, Ga., was found to be healthy with the exception of one corner near the kitchen garden, where about 80 per cent of the plants had the mosaic. Investigation revealed the fact that a patch of green chewing cane had been growing adjacent to the D 74 at that corner during the preceding year. The green cane was found growing elsewhere on the farm this year, and examination showed that every plant had the mosaic disease. Clearly the D 74 had become infected last year, the disease had survived the winter in the stubble, and the shoots were diseased when they appeared again.

At Washington, D. C., 17 varieties of cane, all diseased, are growing in an insect-proof quarantine greenhouse.[1] From time to time healthy sugar-cane plants in pots have been taken into the greenhouse and left exposed to the contagion. Invariably they show the incipient symptoms of the disease on the average in 17 days, proving that the incubation period is from two to three weeks. As has been mentioned elsewhere, sorghum and wild grasses taken into this greenhouse have also become infected. Much more evidence of this kind could be adduced, but it is believed to be sufficiently clear that infection by some principle present only in diseased plants is responsible for the appearance of the disease in formerly healthy individuals.

TRANSMISSION OF MOSAIC IN DISEASED SEED PIECES.

Experiments in Porto Rico[2] and elsewhere have repeatedly demonstrated that cuttings from infected stalks invariably give rise to infected plants. The young shoots are seen to be mottled as soon as they appear. These are referred to as primary infections. The fact is one of far-reaching importance, and to it must be attributed the spread of the disease to new regions, remote from any infected cane, by shipments of cane seed. The use of diseased stalks for propagating results in wider distribution of diseased plants on the same plantation from year to year and insures the survival of the virus, even in the absence of secondary infections. Transmission of the disease in cuttings is a fact, the importance of which can not be overemphasized in view of its obvious bearing on control measures.

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1 Insects were present in the greenhouse.

2 Stevenson, John A. The "mottling" disease of cane. Porto Rico Insular Exp. Sta. Ann. Rpt. 1916-17, pp. 40-77. 1917. [Literature], pp. 76-77.

TRANSMISSION OF THE DISEASE BY CARRIERS.

It can be proved mathematically that by the law of chance the percentage of diseased plants in a plantation would tend to remain stationary from year to year provided there was no conscious or unconscious selection,[3] if the spread of the disease depended wholly upon the use of infected cuttings. Nature has provided a far more efficient method for the quick dissemination of the malady. Secondary infection, i. e., infection due to the inoculation of healthy plants during the growing season, goes on at a more or less rapid rate wherever the disease has been observed. Secondary infections are easily determined as such when the plants are young. In the case of plants infected in the greenhouse it has been determined that only the leaves which were immature at the time of inoculation and leaves subsequently formed become mottled. When a plant is found with normal leaves up to a certain point on the stalk and mottled leaves above that point it is a clear case of secondary infection. Since in older plants the lower leaves are gradually sloughed off until only a relatively small terminal tuft of the youngest leaves remain when the plant approaches maturity, this method is obviously limited to young plants or to plants with green leaves still present above and below the point of inoculation.

The rate of spread of the disease, as indicated by these secondary infections, varies greatly. Fields are frequently seen in which there has been apparently no secondary infection during an entire growing season. As an extreme case illustrating this point, the fields near Cienfuegos, Cuba, may be cited. There the disease has merely survived by the planting of infected seed pieces, and secondary infection, if it goes on at all, is certainly very limited. Even in Porto Rico, during the height of the epidemic, secondary infection was at a standstill in some localities for a year or more. On the contrary, whole fields of healthy cane became infected in the short space of a month or two. Such a case was the invasion of the variety test field at Santa Rita, Porto Rico, previously mentioned. No doubt the explanation for this great variation in rate of spread by secondary infection must be sought in the mechanics of inoculation. Up to the present no positive proof of the method by which inoculation is accomplished in nature has been brought forward. Reasoning from the fact that new cases often appear at some distance from diseased individuals, it would seem that some agent or carrier is necessary. Mere contact of diseased and healthy plants does not serve to communicate the infection from the former to the latter. In no case has the planting of healthy cuttings in the same pots with diseased plants resulted in the new plants becoming diseased. The same holds true for plants in the field, where healthy plants are often seen with their leaves mingling freely with the leaves of diseased plants for a time much longer than the inoculation period for mosaic, but with no evidence of transference of the inoculum. It is evident that special conditions are necessary in order that the disease can be communicated to healthy plants.

Field observations indicate that acceleration in the spread of the mosaic

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[3] Selection is employed where the disease is not recognized. During the beginning of the epidemic in Porto Rico, when sugar was bringing an unprecedented price, it was learned that the manager of one of the mills was instructed to grind the best cane and save the poorest for seed. The "poorest" was undoubtedly that attacked by mosaic.

disease is accompanied with or preceded by severe insect infestation. The cane leafhopper (*Tettigonia* sp.) in particular has been noticed to accompany the rapid spreading of the disease. This evidence is incomplete, but it is supported by the fact that 10 healthy plants placed in insect-proof cages in the greenhouse at Garrett Park, Md., did not contract the disease, while five control plants outside of the cages, but otherwise under identical conditions, all became infected. Aphids were abundant on the diseased cane in this greenhouse, and a few leafhoppers were present. A great deal of experimental work remains to be done before formal proof of the responsibility of any particular insect or insects for the transmission of the disease can be offered.

SOIL RELATIONS.

There has been no indication that the contagion persists in the soil after a crop has been removed and the stubble plowed up. Fields that have been veritable hotbeds of infection after being plowed up and planted with clean seed have only a few scattered cases, which can be accounted for by faulty seed selection. Healthy cuttings planted in the soil of pots from which badly diseased specimens had just been removed grew without any evidence of the disease. The virus does not live over in the soil and it is doubtful whether it exists there at any time. In this respect the mosaic does not by any means present the practical difficulties in the way of control measures to be met with in root-rot. Root-rot, in fact, is to be regarded as a far more serious problem for the Louisiana cane planter than mosaic on this account.

RELATION TO DISINFECTANTS.

Treatment of infected seed pieces by soaking in strong Bordeaux mixture or corrosive sublimate previous to planting has had no effect on the course of the disease. All shoots were typically mottled as soon as they appeared. It was hardly to be expected that superficial disinfection could influence the virility of the infectious principle when all our evidence indicates that the latter permeates the internal tissues, or at least the vascular systems of affected plants.

RELATION TO FERTILIZERS.

Many experiments[1] have been performed in Porto Rico to determine the effect of applying fertilizers, since the claim was made by many planters that mosaic was due to insufficiency of plant nutrients in the soil. Filter-press cake, sulphate of ammonia, and lime in various combinations, together with turning under cover crops and good tilth, had no noticeable effect on the disease as compared with control plats. Standard complete fertilizers were also tried. Beyond a slight stimulation in growth and the darker green color of the treated plants, there was no observed effect. Diseased plants may be expected to respond to good growing conditions the same as healthy ones, but the same constant difference between healthy and diseased plants is maintained under all conditions. The diseased stalks remain below the average weight for healthy

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[1] Stevenson, John A. The "mottling" disease of cane. Porto Rico Insular Exp. Sta. Ann. Rpt., 1916-17, pp. 40-77, 1917. [Literature] pp. 76-77.

stalks and are just as capable of spreading the disease. Liming the soil has no more effect on diseased plants than the application of fertilizers.

Control.

It is interesting to note that in Java long experience has demonstrated that the disease can best be held in check by careful selection of healthy plants for seed and by replanting fields with cuttings taken from the same field, in preference to buying cuttings of unknown origin or moving the cuttings from field to field on the same plantation. The use of such methods practically amounts to tacit admission of the infectious nature of cane mosaic, although it is ascribed to "bud variation." The facts which have most impressed the Dutch planters are that cuttings from diseased stalks always produce diseased plants and that careless importation of seed is apt to result in increased amounts of the disease.

In the Hawaiian Islands also the disease is controlled by selection of clean seed and the use of resistant varieties.

Measures for controlling the mosaic disease recommended in the following pages are not haphazard expedients, but have been used with very satisfactory results in Porto Rico for more than a year. Planters there have paid a heavy price to learn them, and it is urged that planters of sugar cane in the United States cooperate to prevent a possible epidemic. Indifference to the situation may result in the cane growers being confronted with the fact that it is too late to practice seed selection, as is already the case in western Porto Rico. At present, it will work no particular hardship on the planters to take steps that will reduce the disease to a minimum.

Elimination by roguing.

Roguing consists of pulling out infected plants, root, stem, and branch, and throwing them down between the rows. It is based on the fact that as soon as the plants are wilted they are no longer dangerous as a source of infection. This method is applicable only to fields in which the disease has not obtained a strong foothold. It is not recommended for fields in which the number of infected plants exceeds 5 per cent in half-grown to mature cane or 20 per cent in young plants just sprouting. The size of the field and the condition of surrounding fields with reference to the occurrence of the disease in them must also be taken into consideration. When the field is quite small or consists merely of a few rows or plants of a new variety being propagated for trial on a plantation scale, it should be rogued even if 100 per cent of the plants are infected. Such plants are a constant menace to plants in surrounding fields. In large fields where the proportion of diseased individuals is greater than 20 per cent, roguing is impracticable, not because the plants are any less potent as sources of infection, but because diseased plants produce millable cane, and to destroy considerable quantities of such plants would probably result in greater financial loss than would be sustained by the reduction in yield due to new cases. Large fields with a high percentage of diseased plants should be allowed to mature, but no cane from such fields should be saved for seed.

It is suggested that the following schedule of inspections and roguing be put into operation: In the spring, just as soon as all of the plants have sprouted,

the fields should be inspected by passing up and down the rows. All diseased stools should be pulled out of the ground and cast down between the rows. If this first inspection is carried out in a thorough manner the field will be completely freed from the disease provided no secondary infections are going on. Since there are as yet no certain means of determining the latter fact, a second inspection is essential. It should be made from 25 to 30 days after the first, a lapse of time sufficiently in excess of the incubation period for mosaic to insure recognition of the disease in plants inoculated prior to the first inspection. If no diseased plants are found during the second inspection, it can be assumed that secondary infection is not in operation and that the remaining plants will continue healthy. If diseased plants are found, however, it establishes the fact that secondary infections are going on. The field should be rogued as before, and a third inspection made after the same interval, i. e., 25 to 30 days. If the carriers remain active it may be necessary to repeat the process several times, and owing to the impossibility of recognizing the disease in inoculated plants before the end of the incubation period it is certain that plants which have become infected just before the inspection is made will escape detection. This emphasizes the necessity for making the first inspection early, preferably before leafhoppers or other sucking insects have appeared on the plants.

This procedure may result in perfect control or eradication of the disease or in partial control, the element of uncertainty being due to our inability to control the carriers. By it their activity can be rendered less effective by reducing the sources of inoculum to a minimum. It has effectually halted the progress of the disease into new territory in Porto Rico.

ELIMINATION BY GRINDING ALL CANE AND SECURING CLEAN SEED.

In badly infested sections the problem is manifestly complicated. Where 25 to 60 per cent or more of the plants in large fields are diseased, roguing is obviously out of the question. Such plantings should be allowed to mature. Every stalk of it should be ground, however, and the stubble plowed up and killed. This means, of course, that carefully selected seed must be imported for replanting. Fortunately there is still an abundance of healthy stock in Louisiana and other cane sections in the United States. As a result of its recent exhaustive survey for mosaic disease, the Office of Sugar-Plant Investigations of the Bureau of Plant Industry is in a position to furnish information on the nearest or most accessible source of clean seed for any region. Data have been secured on the prevalence of other diseases and insect pests in all cane regions, so that reasonable security against the dissemination of other cane maladies is assured.

EXCLUSION.

There are at the present time (October, 1919) a number of large cane areas in the United States not yet invaded by the mosaic disease. Cane planters in these areas should urge the enactment of State legislation prohibiting the importing of cane into them from any source whatever until such time as it can be accompanied by an authentic certification of health. Such areas include the entire Bayou Teche district and the parishes to the north in Louisiana, consisting of St. Mary, Iberia, Vermilion, Lafayette, St. Martin, Acadia, St. Landry,

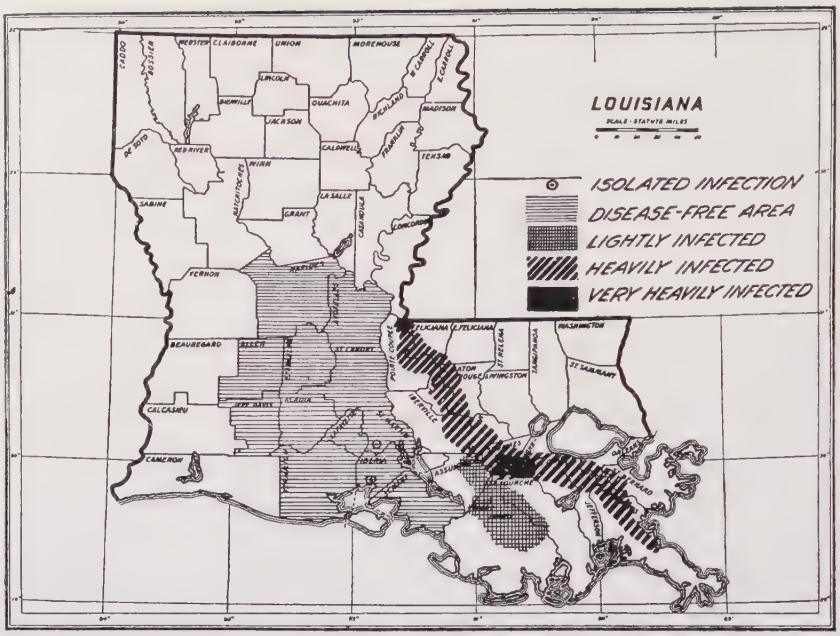

Fig. 3. Map of Louisiana, showing the location of diseased areas of sugar cane in that State.

Avoyelles, and Rapides. This is, of course, the most important disease-free area. (Fig. 3.) Other similar areas are the entire State of Mississippi with the exception of Biloxi; the entire State of Alabama except a small locality near Muscogee, Fla.; the entire State of Georgia except Grady County; and all parts of Florida other than those indicated in Figure 4.

ERADICATION.[1]

Where the disease is present in small amount and in few well-defined areas, the possibility of quick and complete eradication exists. Such conditions are found in Mississippi, Alabama, and Florida. (See Fig. 1.) The cane in these areas should all be ground during the present harvesting season and the stubble plowed up. As a precautionary measure, some crop other than a grass should be grown on the land for one year, after which cane may again be grown with safety. The two small infested areas in Alabama and Mississippi offer no difficulty at all. They can be destroyed with practically no loss to the owners, and the assurance of healthy crops in the future more than offsets the inconvenience of growing some other crop on the land now occupied by infected cane. The success of the measure in Florida is made possible by the present organization of the State plant board, which has already met the test of successfully handling more serious problems.

ELIMINATION BY PLANTING IMMUNE VARIETIES.

Success of the control measures suggested up to the present depends entirely upon the whole-hearted cooperation of all cane growers. There yet remains a

[1] In so far as it applies to the regions indicated, we concur in this suggestion by Mr. Wilmon Newell, Plant Commissioner of Florida.

method, applicable only to certain regions, by which a planter can make himself wholly independent of any default on the part of his neighbors. A few varieties of sugar cane have been discovered that are absolutely immune to mosaic under all conditions. Most of them are of the type referred to as Japanese cane. Their origin is obscure. They have certain characteristics in common. All are tall growing with slender stalks. They stool abundantly, ratoon well, and produce an enormous tonnage. The sucrose content is not so high as in some of the broad-leaved canes, but in sugar per acre they take first rank with the best existing varieties. The Kavangire, Zwinga, Uba, Cayana 10, and numerous others imported by the office of Foreign Seed and Plant Introduction are included among these varieties. The Cayana 10 has already won a well-deserved popularity among the farmers of the cane-sirup section in Georgia and northern Florida on account of its high tonnage and the excellent quality of sirup made from it. The Kavangire is used for manufacturing sugar in Argentina. Its estimable qualities are brought out in Table 3.

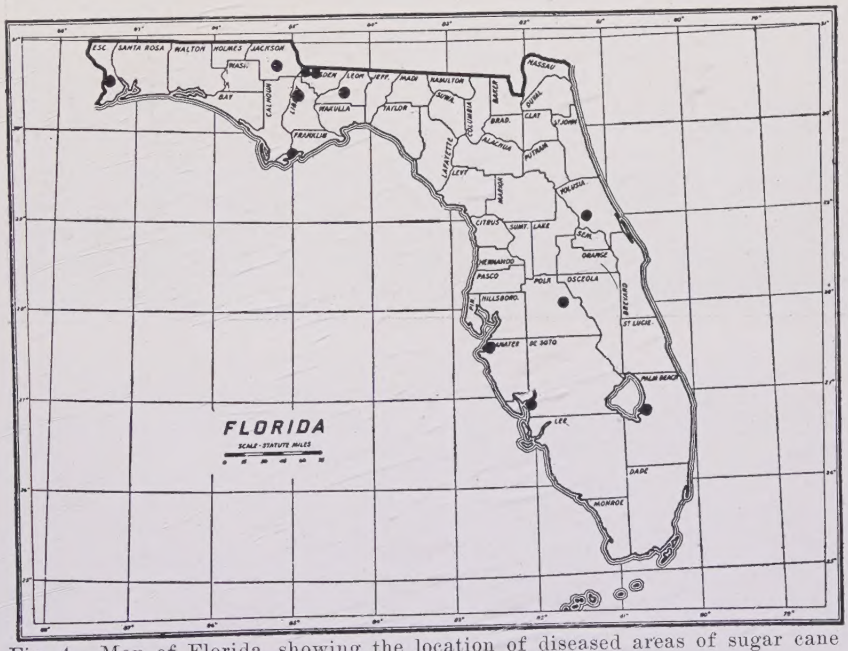

Fig. 4. Map of Florida, showing the location of diseased areas of sugar cane in that State.

Fig. 5. Kavangire sugar cane (immune), at the left; G. C. 1070 (susceptible), at the center; Java 36 (susceptible but tolerant), at the right.

TABLE 3.—YIELD AND ANALYSIS OF KAVANGIRE SUGAR CANE COMPARED WITH OTHER STANDARD VARIETIES.[1]

Variety	Average Weight of Single Canes	Weight of Cane per Hectare[3]	Brix Scale	Sucrose	Purity	Weight of Sugar per Hectare[3]
	Kilos [2]	Kilos [2]	Deg.	Pct.	Pct.	Kilos [2]
Kavangire	0.68	166,850	17.84	15.68	87.5	16,090
Java 36	1.36	117,300	17.55	15.34	87.4	11,024
Java 213	0.84	95,725	17.54	15.79	89.96	9,533
Louisiana 60	1.87	118,125	17.32	15.34	87.05	10,973
Java 139	1.10	89,975	16.67	14.41	86.40	7,853
Rayada (Louisiana Striped)	1.71	94,150	18.26	16.39	89.74	9,714
Java 234	0.95	75,550	19.02	16.66	87.08	7,703
Morada (Louisiana Purple [?])	1.28	72,925	16.69	14.54	87.07	6,354
Honduras	1.23	76,575	16.98	14.36	83.88	5,998
Java 100	1.00	79,675	16.03	13.57	89.68	6,456
Tamarin	0.95	33,325	19.15	17.50	91.54	3,940

[1] Bennett, A. G. Informe de subestaciones para el año 1914. In Rev. Indus. y Agr. Tucuman, año 5, pp. 208-209. 1914.

[2] A kilo is the equivalent of 2.2 pounds.

[3] A hectare is the equivalent of 2.47 acres.

Figure 5 shows a row of Kavangire cane on the left; a susceptible variety, G. C. 1070, at the center; and a diseased but tolerant variety, Java 56, on the right. Unfortunately, the Kavangire variety is a long-season cane and therefore not suitable for conditions in Louisiana. The possibility of breeding more early maturing varieties from these parents is being investigated.

Several of the broad-leaved varieties of cane originated at the Sugar Cane Experiment Station at Aubudon Park, La., appear to be immune. Although equally exposed to the contagion, no individuals of these varieties have become affected, while practically every plant of the scores of other varieties surrounding them is diseased. They have been under observation for too short a time, however, to demonstrate that their apparent immunity is permanent.

Kavangire, a Cane Variety Immune to Yellow Stripe Disease.

During the past few months reference has been made to a cane variety called Kavangire, which was attracting attention in Porto Rico owing to its immunity to Yellow Stripe disease. Such descriptions as were given indicated that Kavangire was similar to the spindling cane known locally as Uba. The matter is clearly set forth in a circular recently issued from the Porto Rico Agricultural Experiment Station. Under the heading, "Japanese Cane," we read:

"Several years ago the U. S. Experiment Station, Mayaguez, P. R., received from the U. S. Department of Agriculture, Washington, D. C., a variety of Japanese cane, which was planted extensively in the Southern States for forage. Two years ago the Station received from George L. Fawcett, former pathologist, now connected with the Station at Tucuman, Argentine, some Japanese cane from over there. It is known as Kavangire, and is grown very largely in Argentine, where they are greatly troubled with the mottling disease that is giving us at present considerable concern in Porto Rico. Both of these canes are free from the disease at the station in Mayaguez. When fully mature they appear very much alike, but when younger the difference is more noticeable. The cane received from the U. S. Department of Agriculture may be the one known as Zwinga. Until we are better informed we will, at least, put it under that name. We have received a few tons of this latter cane from the U. S. Experiment Station at St. Croix, Virgin Islands, and distributed it widely here. Dr. Longfield Smith, the director, writes that it is producing 50 tons to the acre. The sucrose content of same is 12 per cent. He considers this remarkably good when the cane is not mature at present; also the yield is good for St. Croix, where they have an average rainfall of less than 50 inches. This cane, with us at Mayaguez, has shown the following analysis: Brix, 15.4; per cent sugar, 12.5; purity, 81.1. We have no estimates of the yield at present. The Kavangire at Mayaguez has given, from the plot, a yield calculated at 83 tons per acre. The next highest of a large number was 52 tons. During the present crisis we urge the planting of these two canes, and we are making every effort possible to secure seed. They have the very high recommendation that they are immune to the

mottling disease. On the other hand, they are very slender canes, which will increase the labor of harvesting; also, the sucrose content is much lower than some of our seedling canes. However, with their tonnage and freedom from disease, they are, from present outlook, the greatest producers of sugar in those sections of the island that are afflicted with the mottling disease.

"We have at the Station also two Java seedlings that, while not immune to the disease, yet the damage caused by it to them is slight. One, especially, Java 36, gave a yield of 52 tons of cane, and the sucrose content was 17.25 per cent. The damage from the mottling disease was small. A number of other seedlings, also, are promising, namely, Barbados 1753, Guanica Centrale 1480, Guanica Centrale 1313, Mayaguez Station No. 3 and No. 4. From the many canes bred at the Insular Station, Rio Piedras, Guanica Centrale at Santa Rita, Fajardo Sugar Co., Fajardo, and U. S. Experiment Station, Mayaguez, it is very probable that we will be able to select canes that, while giving large yields in sugar per acre, will at the same time prove but slightly subject to the mottling disease. In the meantime, our best hope is in the Japanese canes while we are seriously affected by this trouble, and every planter living in a section where this disease prevails is urged to undertake growing the Japanese canes for the purpose of securing seed for more extended planting during the coming year. In this effort the U. S. Experiment Station will lend every aid possible, distributing all the seed that can be possibly secured both at home and those obtained from the Station in St. Croix. We must remember, however, that the Japanese varieties are inferior canes and we must seek good improved canes that, while perhaps only partially immune to the mottling disease, are sweeter, more easy to harvest and far superior in milling qualities and yield of sugar to the Japanese canes."

[H. P. A.]